

Upper Extremity Repetitive Strain Injuries in Connecticut 1996, Extent and Costs

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Table of Contents

Abstract	3
List of Abbreviations	4
List of Tables	5
Significant Findings	6
Usefulness of Findings	9
Body of Report	11
Study Aim 1: RSI Surveillance	11
Study Aim 2: Factors Affecting WRMSD Claims Reporting	24
Study Aim 3: The Economic & Social Burden of WRMSD	33
Study Aim 4: WRMSD Medical Care & Ergonomic Intervention Survey	45
Study Aim 5: RSI Intervention Trial	51
Additional Studies: Biomechanical and Work Organizational Factors	53
Conclusions	54
Acknowledgments	54
References	55
List of Present and Possible Future Publications	58
Appendix 1: Biomechanical, Psychosocial & Organizational Risk Factors for WRMSD.	59

Abstract.

A 1996 Connecticut population based, randomized telephone interview survey of self reported, chronic work related musculoskeletal disorders (WRMSD) of the neck and upper extremities was performed to replicate and extend the 1988 National Health Interview Survey Occupational Health Supplement (NHIS-OHS). Nested in this survey were discrete case control studies to examine special areas of interest. Self reported WRMSD were widely prevalent in the Connecticut working population, and far exceed injury claims entered into the state's workers' compensation system. WRMSD appear to receive medical treatment largely within the private sector, rather than under workers' compensation insurance. Elevated WRMSD risks are seen in female gender, among Financial Services/Insurance Industry workers, and manual laborers. The population based estimated etiologic fraction of all chronic, subacute onset WRMSD attributed solely to work was 32% by medical providers.

Seriousness of the WRMSD injury is an important factor influencing filing of workers' compensation injury claims. Industry sectors associated with increased injury reporting were Manufacturing, Transportation, and General Trades; with decreased reporting in the Agriculture, Construction and Mining and the Financial, Insurance and Real Estate Sectors. Demographically, workers with greater educational and personal economic resources and family support, reported injuries less often. Familiarity with the workers' compensation system did not prove a significant factor in multivariate analyses. Working in more tightly controlled settings where perceived management interest in workers is low was associated with higher injury reporting.

In terms of individual social and economic impact, WRMSD cases had an average of \$489 in annual out-of pocket expenses. Only 57.3% of RSI injuries sought medical treatment. WRMSD cases were treated mostly in the private sector, and only 21% of individuals who had medical visits or procedures reported having them paid by workers' compensation insurance. WRMSD cases reported high levels of impairment in Activities of Daily Living scales, were significantly more likely to have had to change residence for financial reasons, to have lost a car due to finances, to have been divorced, and less likely to have been promoted. Medical care was provided primarily by personal physicians with surgeons, Orthopedists and medical specialists seeing lesser numbers of RSI patients. RSI injury treatment outcomes were examined by type of health insurance plan. A general finding was a lack of significant difference in outcomes between managed care and private insurance plan care. RSI cases were more likely that controls to have worksite ergonomic evaluations and intervention, however, RSI injuries triggered ergonomic interventions in only about 25% of instances. Job safety evaluations, workstation layout and equipment changes, worker training programs and health and safety committee evaluations were utilized in preference to administrative changes in work schedules as preferred ergonomic intervention strategies.

List of Abbreviations:

ADL	Activities of Daily Living
CT	Connecticut
CSRA	The University of Connecticut Center for Survey Research & Analysis
CUSP	Connecticut Upper-extremity Surveillance Project
NHIS-OHS	1988 National Health Interview Survey, Occupational Health Supplement
RSI	Repetitive Strain Injuries
WRMSD	Work Related Musculoskeletal Disorders

List of Tables:

		Page
1A	Sample Survey Distribution by Age and Gender	15
2A	Table 2A. Crude and Standardized Incidence, Prevalence, Risk and Odds Ratio Estimates for Connecticut Neck & Upper Extremity Disorders, NHIS-OHS Prolonged	16
3A	1996 Point Prevalence and Prevalence Odds Ratios of Most Troublesome Body Area, NHIS-OHS Prolonged Cases	16
4A	Point Prevalence, Prevalence Odds Ratio Estimates for Connecticut Neck & Upper Extremity Disorders, NIOSH Definition, Prolonged by Gender	17
5A	Age Cohort Point Prevalence of Prolonged Neck & Upper Extremity Disorders	18
6A	Provider-Called Diagnostic Data, NHIS-OHS Criteria Prolonged Cases, Point Prevalence	19
7A	Distribution of Prolonged WRMSD by Industry Sector Point Prevalence	20
8A	Distribution of Prolonged WRMSD by Occupation. Point Prevalence	21
1B	Workers' Compensation Claim Filing Status by Education	27
2B	Union at Workplace by Filed a Claim	28
3B	Management Concern for Workers by Filed a Claim	28
4B	Easy to Leave Work Briefly by Filed a Claim	29
5B	Industry Sector and Claim Filing.	29
6B	Factor Analysis of Attitudes Towards Workers Compensation	30
7B	Relative Importance of Factor Analysis Constructs	30
8B	Multiple Logistic Regression Analysis of Workers' Compensation Injury Reporting	31
1C	Sample Characteristics, CT, 1996	37
2C	Case Characteristics, WRMSD and Doctor Called WRMSD	37
3C	Social Factors Related to WRMSD, Previous 12 Months	38
4C	Logistic Regression For Social Effects, WRMSD Cases and Controls	39
5C	Odds Ratios for "A Lot" or "Some" Difficulty, Activities of Daily Living, WRMSD	39
6C	Social Benefits for Work-Related WRMSD Cases. CT, 1996	40
7C	Out-of-Pocket Expenses Paid, Due to Injury, WRMSD Cases only, CT, 1996	41
8C	WRMSD Cases with Medical Visits and Procedures by Type of Payment, CT, 1996	42
!D	Medical Utilization For WRMSD Cases	46
2D	Severity of Injury vs. Managed Care Insurance Care	46
3D	Duration of WRMSD Injury by Health Insurance Status	47
4D	WRMSD Case ADL Outcome According to Health Insurance Status	47
5D	Impact on Job by Health Insurance Status for WRMSD Cases	48
6D	Prevalence of Workplace Ergonomic Interventions. CT 1996	48

Significant Findings:

1. RSI Surveillance: The 1996 Connecticut Population Survey.

A 1996 Connecticut population based, randomized telephone interview survey of self reported, chronic work related musculoskeletal disorders (WRMSD) of the neck and upper extremities was performed to replicate and extend the 1988 National Health Interview Survey Occupational Health Supplement (NHIS-OHS). Self reported WRMSD were widely prevalent in the Connecticut working population: the point prevalence of neck and upper extremity symptoms being 11.8%. The point prevalence of prolonged WRMSD (NHIS-OHS criteria) was 7.5%. High risk groups included female gender, the Financial Services/Insurance Industry workers, and manual laborers (including craftsmen, machine operators, and general laborers) also had significant risks. The estimated etiologic fraction of musculoskeletal disorders attributable solely to work was 51.4% by worker self report, and 32% by medical providers. The estimated fraction of potentially compensable musculoskeletal disorders under Connecticut Workers Compensation (those MSD either solely caused by or substantially aggravated by work) was 75.6% by worker self report, and 45.5% by medical providers. WRMSD appear to be largely treated within the private sector, and typically do not enter the state's Workers' Compensation system.

2. Factors Affecting Worker Reporting of WRMSD

The current findings are based on a preliminary data analysis. This analysis indicates that overall, the seriousness of the MSD injury is a predominant factor positively influencing the likelihood of a worker's compensation claim: for example injuries that impacted a worker's activities of daily living, or required time away from work were associated with significantly higher injury reporting rates. Industry sectors showing increased prevalence of workers' compensation injury reporting were the Manufacturing, Transportation and General Trades sectors, with trends towards decreased workers' compensation injury claims reporting in the Agriculture, Construction and Mining and the Financial, Insurance and Real Estate Sectors. Workplace unionization is also more common in traditional manufacturing and trades industry sectors, although it is not clear from this analysis whether unionization itself, or hazards inherent in the work processes of these industries accounts for the observed increases in claims reporting. Government workers, however, a highly unionized group, did not have significantly high workers' compensation claims rates.

Demographically, workers with greater educational and economic resources and family support reported injuries less often. Unmarried individuals, and those with only a high school education or less, reported significantly higher numbers of workers' compensation claims. A worker's knowledge and familiarity with the workers' compensation system generally appeared significant in initial univariate analyses, but did not prove a

significant factor in multivariate analyses. Organizationally, perceived management support for workers and a measure of the general degree of a worker's job decision latitude appeared important. Working in more tightly controlled settings where perceived management interest in workers is low appear to convey higher injury risk; work settings with increased employee decision latitude and high levels of perceived management support for workers appear associated with lower workers' compensation claims rates.

3. Case Control Study of Social and Economic Costs of WRMSD.

The case control study of the social and economic impact of WRMSD found that in Connecticut in 1996, only 10.6% of prolonged WRMSD cases defined by NHIS-OHS criteria had filed workers' compensation claims. WRMSD cases had an average of \$489 in annual out-of-pocket expenses. WRMSD cases were medically treated primarily in the private sector, and only 21% of individuals who had medical visits or procedures reported having them paid by workers' compensation insurance. In terms of personal impact, WRMSD cases reported much higher levels of impairment in daily tasks under the Activities of Daily Living scales, with odds ratios ranging from 8.2 to 35.2. Cases were significantly more likely to have had to change residence for financial reasons (OR=2.41), to have lost a car due to finances (OR=2.45), to have been divorced (OR=1.91), and less likely to have been promoted (OR=0.45).

4. RSI Medical Care & Ergonomic Intervention Study.

Medical treatment was sought by a slim majority (57.3%) of self-reported injured workers. In general, medical care for injured workers was provided primarily by personal physicians and generalists, although surgeons, Orthopedists and medical specialists saw lesser, but substantial number of RSI patients. Up to a quarter of workers saw alternative providers for their medical care. RSI injury treatment outcomes were examined from the perspective of the type of health insurance plan under which this care was administered. RSI injury treatment under managed care plans was contrasted with treatment provided under private insurance plans. A general finding was that there was not a significant difference in outcomes between these two general types of insurance plans. A variety of measures were examined, including duration of illness, affect on activities of daily living, or impact on the workers' job.

The prevalence of injury related worksite ergonomic interventions in response to RSI injuries was examined. Injured upper extremity RSI case were seen to be 2 to 2 ½ times as likely as uninjured workers to have worksite ergonomic evaluations and intervention. In general, however, RSI injuries triggered ergonomic interventions in only about 25% of instances. Job safety evaluations, workstation layout and equipment changes, worker training programs and health and safety committee evaluations were all significantly utilized. Employers did not seem to favor administrative controls such as changes in work schedules as a preferred ergonomic intervention strategy.

5. RSI Clinical Intervention Trial.

This study project is a randomized clinical trial, to determine the relative efficacy of conservative medical treatment for RSI in computer office workers (medical treatment only, or physical/occupational therapy), and keyboard technique retraining (an “intrinsic” ergonomic intervention aimed at changing work practices). The goal is to determine the most clinically effective and cost effective treatment strategy or combination of treatment strategies for RRSI disorders. Estimates of the relative benefits, costs and complications of various strategies would be developed. Short and long term outcomes measured were performance status at work, clinical status, an psychological status.

This study project was initiated but not completed during the time period funded by grant 5 RO1 CCR112118-03. Results for the study including significant findings are not available at the time of writing. The study commenced in April 1997 and because of funding problems, ended in February 1999, with patient recruitment at about 1/3 of that originally targeted.. Current plans are to complete follow up of the presently enrolled study patients with UConn Division of Occupational Medicine resources, and to analyze the existing data from this sample, although these results will likely not be available until the year 2000.

6. Additional Studies: RSI in Relation to Biomechanics and Work Organization

An additional nested case control study was performed, based on the 1996 population based Survey of the Connecticut working population: This was a case-control study of Ergonomic and work organizational factors as they influence the risk of WRMSD. In this Ergonomic case control study, univariate and multivariate statistical modeling demonstrated consistent positive associations with biomechanical exposures including: Static Postures (ORs 2.00-5.45), Repeated Pushing, Pulling, Lifting (ORs 1.86-12.75), and Repeated Neck Bending (ORs 1.07-12.8). Psychosocial and work organizational factors showing consistent positive associations were: Demands (ORs 1.26-1.59) and Organizational Support (ORs 0.53-0.79). Decision Latitude showed some associations with WRMSD risk, but not consistently across all models tested (ORs 0.30-0.49).

Usefulness of Findings:

Estimates of the true prevalence of WRMSD are essential to understand the overall impact of these conditions on the U.S. working population, and are therefore a key factor in public health policy decisions and planning. These estimates guide resource allocation for research and interventions necessary to address such workplace problems. Previous work based primarily on reports from workers' compensation insurance systems has indicated that WRMSD are widely prevalent in the general working population, and are among the more common causes of prevalent musculoskeletal disorders. The results of the current research indicates that such commonly held estimates may in fact be underestimates by an order of magnitude. On the whole, WRMSD appear to be far more prevalent than was heretofore suspected.

Whereas previous research in the main focused primarily on distal hand and wrist WRMSD, a useful feature of the current study is its inclusion of the entire spectrum of hand, arm, shoulder and neck WRMSD, presenting a more balanced overall picture of the scope of upper extremity and related disorders. Neck and shoulder WRMSD are seen to be a significant and important problem in the workplace. The 1996 Connecticut prevalence survey supports findings from previous research, and points to an aggregation of chronic WRMSD's in high risk industries such as manufacturing, and among blue collar workers, but also in the office work financial sectors, where desk computing is widely employed. There is an excess of risk seen in females, which has also been noted previously.

A corollary of the fact that chronic WRMSD are significantly under reported to worker's compensation insurance systems is that significant cost shifting occurs to private medical insurance carriers, and to the workers' themselves. As such, the true economic impact of WRMSD is understated, likely by an order of magnitude. Externalizing such costs outside the workers' compensation system has significant impacts. It reduces employer economic incentives to prevent WRMSD, since there is typically not an experience rating for other employer-provided health benefit insurance. Lack of reporting of such cases to traditional reporting systems such as workers' compensation and OSHA/ Bureau of Labor Statistics also reduces the ability to target conditions for interventions, for example OSHA inspections, cluster investigations or consultative/educational efforts. There is evidence that WRMSD has significant individual impacts on workers in CT, not only in terms of out of pocket expenses borne, but also in an increased likelihood of loss of home or personal transportation. There appear to be significant social impacts on family life, and the future likelihood of job promotion.

Medical care was provided in large part by workers' personal physicians, with surgeons, Orthopedists and medical specialists seeing lesser numbers of WRMSD patients. An implication of this finding is that greater emphasis should be placed on training medical generalists in workers' compensation injury recognition and management. WRMSD injury treatment outcomes were examined with respect to presence or absence of a

managed care plan. Clear differences were not seen in this analysis, however larger, more accurately delineated studies would be necessary to accurately define such effects, should they exist.

In the survey of ergonomic interventions for WRMSD, injury triggered job safety assessments and interventions in only about 25% of instances. Clearly there is the potential for more widespread use of ergonomic interventions to reduce injury severity, and for future injury prevention. An analysis of biomechanical and work organization appears to confirm that exposure to well-established biomechanical risk factors such as applied force, position, and repetition is associated with WRMSD risk, but interestingly, prolonged static posturing emerges from this analysis as a very significant WRMSD risk, a factor heretofore little appreciated. There is the implication that previous studies of ergonomic biomechanical risks may have been imprecise or incomplete. This is a finding that clearly needs further evaluation. The current analysis also indicates that psychosocial factors, including workplace demands, organizational and co-worker support, and the degree of decision latitude are important as WRMSD injury risk factors. This may have implications for future intervention strategies: reducing both biomechanical and psychosocial risk may be a more effective strategy than focusing solely on engineering controls. Organizational culture and policy themselves may have strong implications for WRMSD prevalence and control.

Study Aim 1: RSI Surveillance:

The Connecticut Upper Extremity Disorder Survey Project: Sample Description, Survey Methods, Incidence and Prevalence

Introduction:

Subacute and chronic work related upper extremity injuries are of increasing concern in the workplace. The great majority of scientific studies in this area predicate analysis on either employer reported or Workers' Compensation reported cases. Such studies, while of obvious practical significance, are subject to significant reporting biases. The number of subacute and chronic work related upper extremity injury cases that neither come to the attention of employers, nor are included in existing Workers' Compensation insurance claims databases remains unclear. Although a significant fraction of reported Workers' Compensation cases originate from larger employers, the majority of employed persons work in relatively small workplaces. These employees are thought likely to have the more unsafe working conditions. In addition to overall reporting bias, the specific types of injuries reported to employers and insurance carriers may not be representative of the actual distribution of injures existing either in the general population or within specific industries, carpal tunnel syndrome being the prime example.

A more accurate estimate of the incidence and prevalence of work related upper extremity disorders, their extent and cost, is based on data from population based studies. Few such surveys exist. The only population based study in the United States of this kind is the 1988 National Health Interview Survey Occupational Health Supplement (NHIS-OHS). (US Dept. of Health and Human Services, 1993). The NHIS-OHS survey of work related upper extremity injuries was a stratified, random in-person household interview study of self reported hand and wrist injuries among 45,000 employed persons.

The present study is a Connecticut state, population based telephone interview survey, designed to replicate and extend this research. Survey case definitions were similar to the 1988 NHIS-OHS survey. The survey goal is to estimate the incidence and prevalence of self reported neck and upper extremity injury and illness by NHIS-OHS criteria, defining both work and non work related prevalence among the Connecticut working population. This study includes data on a wider range of injures than its predecessor: neck, shoulder, arm, elbow and forearm disorders are surveyed in addition to the hand and wrist disorders in the NHIS-OHS study. The current study design also permits improved estimates of the overall impact of these types of problems on the working population, and estimates of the proportion of upper extremity problems attributable to workplace activities (etiologic fraction). The present Connecticut survey had a dual purpose, in that neck and upper extremity cases identified by the survey were utilized as cases in a population based case control study of the social and economic impact of work related upper extremity injuries and a for a survey of ergonomic, psychosocial and organizational risk factors for neck and upper extremity disorders (reported in separate communications: Morse, T. et. al. 1997, Warren, N. et. al 1997).

Methods:

Study Design: Cross Sectional Population Survey

Source of Subjects: Connecticut working population, defined as those reporting employment in full or part time within the previous 12 months, ages 18 years and above. The military, institutionalized individuals, and homemakers were excluded.

Case Definition: Inclusion criteria followed the 1988 NHIS-OHS survey definition. An employed person was considered a case if during the previous 12 months, upper extremity, shoulder or neck pain or discomfort (including burning, stiffness, numbness or tingling) was present and lasted more than one week continuously or 20 or more days in total. Exclusion criteria included any upper extremity symptoms relating to acute trauma. Respondents meeting this case definition were designated as cases with “prolonged” neck or upper extremity disorders. Less detailed data collection was also performed for persons noting any degree of upper extremity pain or discomfort during the previous year. Those experiencing upper extremity symptoms with less than the chronicity necessary to meet the case definition were designated “Transient” cases.

Definition of Work Relatedness: Work vs non work relatedness was determined by self report. Interviewees were asked whether their upper extremity symptoms were attributable to work, or to a variety of personal factors such as illness, arthritis, rheumatism, pregnancy, sports or other off work activity. Analyses were developed for cases attributed solely to work, hereafter designated “SWR”, those with mixed work and non work origin, designated conditions “aggravated” by work, hereafter designated “AWR” and those attributed to non work related conditions, designated “NWR.” In a practical sense, the combination of solely work related conditions and those aggravated by work constitute those conditions potentially compensable under Connecticut Workers’ Compensation insurance.

Diagnostic Data: Following the NHIS-OHS survey protocol (Tanaka, 1997), workers were asked whether they had seen a medical person (physician, chiropractor, physical therapist or other medical person) for their condition, and whether the medical provider considered the condition either caused by or aggravated by work. Interviewees who had seen medical providers, were asked to describe the diagnosis reached, if any, and this data was ICD-9-CM diagnosis coded. No cases were examined or medical records obtained for validation, although this additional study is planned. For analysis, data were grouped as follows: ICD9-CM , 723.0-723.9,728.0-729.9; 781.0-781.9, 840.0-842.19, comprised of Muscle Related & Non Specific Local Pain Syndromes; ICD9-CM, 726.0-727.9, Tendonitis, Tenosynovitis, Ganglion and Synovial Cysts; ICD9-CM 353.0-354.9, 333.6, 356.9, 723.4, Neurologic Disorders and Peripheral Neuropathies (principally peripheral entrapment neuropathies); and ICD9-CM 710.0-722.9, 756.0-756.9, 725, 733.0-733.9 Bone & Joint, Rheumatologic and Arthritic Disorders.

Questionnaire Design: A questionnaire was developed using questions developed for the NHIS-OHS 1988 Household Interview Survey as a base. The questionnaire included demographic variables (age, gender, ethnicity and educational attainment) considered a priori pertinent to the prevalence of upper extremity injury. In addition data was collected for case definition (inclusion and exclusion criteria), as well as survey of the extent and chronicity of upper extremity symptoms, data on medical treatment and diagnosis, employment history, and a survey of workplace ergonomic risk factors. A modified version of the standard OSHA “workplace checklist” (US Dept. of Labor, 1992) served as the basis for questionnaire ergonomic assessment. Questions were then formatted for telephone interview survey administration, and the survey instrument piloted prior to administration. For identified cases with prolonged neck and upper extremity pain, an additional questionnaire was utilized to delineate more detailed data on the work environment, Ergonomic risk factors, and economic, home and psychosocial factors surrounding the specific injury. Office of Management & Budget Standard Industry Classification Codes (1987) were used. Occupational Titles were coded using the Bureau of the Census Classification.

Survey Methods: From May of 1995 through March of 1996, the Roper Center for Public Inquiry of the University of Connecticut performed a random digit dialing telephone interview survey of the non institutionalized CT working population aged 18 years and above. The sampling frame was constructed by partitioning CT into “residential blocks” based on published directories. Sampling of these telephone exchanges was performed using a modified stratified random sampling method, with overall sampling of the geographic area represented by a residential block’s exchanges in proportion to the known CT population residing in the specific geographic area. Thus, in general, if 10% of the CT population lived in the area covered in a directory, 10% of the exchanges were chosen from that area. The geographic distribution used in sampling was based on estimates of the distribution derived from U.S. Census figures for CT townships. Once working residential blocks were identified, telephone numbers were generated at random within each block. A household was given six distinct opportunities to be contacted before a substitution was made for it. Once determination was made that the household did in fact contain an eligible respondent, a random selection- unbiased on age, was made among the eligible respondents. Telephone interviewing took place in the evenings on weekdays, and on weekends. This avoided bias in selecting people only at home at certain times, and allowed daytime weekday workers, a major element in the CT working population, to be sampled. If a given phone number did not result in an interview, for whatever reason, a substitution was made for it within the same working residential block. Because of higher response rates among females vs male respondents, males and females were sampled in approximately equal numbers, desirable because of generally lower WRMSD injury rates among men. The geographical sampling method therefore results in simple random sample stratified by gender.

Data Management & Analysis: Data was entered into a computerized database and verified in duplicate. It was also screened for logical errors. Data coding included age in deciles, and educational attainment was coded in 5 levels by U.S. Census standards. Incidence density, point and period prevalence estimates, standard errors, and 95% confidence intervals were computed (Kleinbaum et.al., 1982). For cases, incidence

density calculations were performed with person years of observation prior to reported onset of the disorder. Incidence density ratios and prevalence odds ratios were calculated for selected contrasts (Kleinbaum, et.al., 1982, Dever, 1984). Chi-square analysis for stratified samples were performed using the Mantel Haentzel method. Data analysis was initially performed stratified by gender. For main effect comparisons, this proved not significantly different from a data analysis treating the data as a simple random sample: i.e. the design effect range for main effect comparisons of prolonged WRMSD, such as by gender and age cohort, or ethnicity by gender was 0.994 to 0.997. An analysis treating the data as a simple random sample is presented here. Initial univariate analyses, followed by a stratificational analysis, and then multivariate analysis using logistic regression were performed. Rates and contrasts not significantly different from unadjusted values are presented in their univariate form. For logistic regression, backwards conditional selection of variates and interactions was used. For comparative purposes, direct age and sex standardization against a 1995 referent for the employed U.S. Population was performed. Statistical calculations were performed using SPSS and SAS on IBM compatible computers.

Results:

Response Rates:

Among telephone contacts there were 22% refusals for interview, giving an 78% interview response rate. Non response due to inability to contact a specific number led to an overall 66% study response rate. To characterize non response an analysis of successive "waves" of responders was performed by key variables (Brenner, 1995). Pilot data as well as this analysis showed somewhat greater difficulty contacting male respondents. An analysis of the six successive waves of respondents based on the number of phone call attempts before successful contact, did not show any significant differences with respect to other demographic variables including, age, educational attainment, and ethnicity. Key study variables, such as the percentage of respondents reporting work related disorders or filing a Workers' compensation claim, or the likelihood of being an upper extremity case with prolonged pain or discomfort showed no significant variation among successive waves of respondents.

Survey Demographics:

The age and gender distribution of the 3200 Connecticut working persons interviewed is given in Table 1A. This sample distribution is similar to that documented for the general employed population (U.S. Bureau of the Census, 1995). The final sample survey proportions of male and female workers approximates published census estimates for the currently employed Connecticut population (survey males 52.8%, CT 52.1%; survey females 47.9%, CT 47.2%). Sample survey demographics by ethnicity, however,

Table 1A. Sample Survey Distribution By Age and Gender

Sample Survey				Gender			
Age							
Age, Years	N	%	Cum. %	Male	%	Female	%
18-19	53	.017	.017	18	.340	35	.660
20-29	518	.167	.182	275	.531	243	.469
30-39	891	.284	.466	476	.534	415	.466
40-49	829	.264	.729	425	.513	404	.487
50-59	525	.167	.897	279	.531	246	.469
60-65	288	.092	.988	149	.517	139	.483
>65	37	.012	1.000	14	.405	22	.595
Total	3141	1.00		1637	.521	1504	.479

Abbreviations: N=Sample Size; Cum.%=Cumulative Percent of Cases. Cases with missing observations=60.

show evidence for undersampling of non white respondents: 84.7% of respondents categorized themselves as white, 5.8% as Black, and 3.7% as Hispanic. These two latter figures are just over half that expected from census data. Altogether “non-white” ethnic groups comprised 15.3% of sample respondents. Self reported educational attainment was measured as a surrogate for socio-economic status. This showed somewhat higher sampling rates in better educated respondents. As compared to population standards, there were deficits of persons with less than high school education, and an increase in those with college and post graduate work. The percentage of persons completing high school is comparable to population norms.

Overall 1996 Connecticut WRMSD Prevalence and Incidence

The 1996 Connecticut point prevalence of neck and upper extremity disorders of all types was 11.8%. 4.3% of these were individuals with transient symptoms, and 7.5% met NHIS-OHS criteria for prolonged pain or discomfort: pain present for more than a week continuously, or more than 20 days within the preceding year. Some 69% of cases with prolonged pain or discomfort had seen a medical provider for the condition, while only 50.5% of those with transient symptoms had consulted a medical provider. Overall crude, unadjusted 1996 incidence and point prevalence of self reported cases with prolonged and transient neck and upper extremity disorders by self reported work related status is given in Table 2A along with rate ratios and odds ratios. Among the current Connecticut working population, self reported, work related neck and upper extremity disorders were 55% more common than self reported non work related disorders. The prevalence of self reported work aggravated disorders is similar in magnitude to the entirety of non work related disorders. Prevalence odds ratios indicate that both self reported disorders caused by work and the combination of potentially compensable disorders either caused or aggravated by work is significantly increased over non work related problems. Overall, the 1996 point prevalence of potentially compensable prolonged neck and upper extremity conditions was 5.5% of the Connecticut working population. Only 31 of 377 individuals with prolonged upper extremity pain by NHIS-OHS criteria filed Workers’ Compensation claims, some eight percent of the total group.

Table 2A. Crude and Standardized Incidence, Prevalence, Risk and Odds Ratio Estimates for Connecticut Neck & Upper Extremity Disorders, NHIS-OHS Prolonged

1996 Incidence					1996 Point Prevalence			
Case Category	n	ID	I	SE	Case Category	n	P	SE
<u>Transient</u>					<u>Transient</u>			
SWR	35	.011	10.94	1.85	SWR	38	.012	.002
AWR	15	.005	4.69	1.21	AWR	32	.010	.002
NWR	35	.011	10.94	1.85	NWR	67	.021	.003
<u>Prolonged</u>					<u>Prolonged</u>			
SWR	61	.020	20.20	2.59	SWR	100	.031	.003
AWR	26	.009	8.61	1.69	AWR	77	.024	.003
NWR	28	.009	9.27	1.75	NWR	64	.020	.002
<u>Prolonged US Standardized</u>					<u>Prolonged US Standardized</u>			
SWR	61	.019	19.02	2.44	SWR	100	.028	.003
AWR	26	.010	9.97	1.96	AWR	77	.022	.002
NWR	28	.008	8.02	1.51	NWR	58	.018	.002

1996 Connecticut Ratios

Incidence	IDR	p	95%CI	Prevalence	POR	P	95%CI
SWR/NWR	2.17	.03	1.20,3.14	SWR/NWR	1.58	.005	1.14,2.19
S&AWR/NWR	3.10	.01	1.78,4.42	S&AWR/NWR	2.86	.001	2.13-3.87

Abbreviations: n=number of cases, ID= incidence density; I=Incidence per 1,000 cases per year; P= point prevalence; SE=standard error of estimate. SWR=Solely Work Related; AWR= Work Aggravated; NWR= non work related cases. OR=Odds Ratio; IDR=Incidence Density Ratio; POR=Prevalence Odds Ratio. P=significance level; 95%CI is 95% confidence interval of the estimate; EF=etiologic fraction. Incidence rates are based on 3020.38 person-years of observation; prevalence on the sample of 3200 interviewees.

For new onset neck and upper extremity disorders in 1966, incidence rates show an approximate two fold increase in occurrence of work related vs. non work related neck and upper extremity problems in the Connecticut working population. Risk estimates based on incidence density measures are somewhat higher than their corresponding prevalence odds ratios. The point prevalence of upper extremity pain according to anatomic location for survey cases meeting the NIOSH/NCHS case definition of prolonged pain or discomfort is examined in Table 3A. Comparing cases reporting their Table 3A 1996 Point Prevalence and Prevalence Odds Ratios of Most Troublesome Body Area, NHIS-OHS Prolonged Cases

	SWR				NWR				POR	p	95%CI
	n	P	SE	CI	n	P	SE	CI			
Neck	32	.010	.002	.008,.014	15	.005	.001	.003,.007	2.14	.01	1.12,4.15
Shoulders	14	.004	.001	.002,.006	12	.004	.001	.002,.006	1.17	.69	.51,2.69
Elbow/FM	14	.004	.001	.002,.006	11	.003	.001	.001,.005	1.27	.54	.54,3.00
Wrist	22	.007	.002	.004,.01	4	.001	.001	0,.002	5.53	.001	1.81-18.9
Hands	18	.006	.001	.004,.008	22	.007	.002	.004,.010	0.82	.52	.42,1.59

Abbreviations: n=number of cases; P=point prevalence; SE=standard error; CI:95% confidence interval of point prevalence; POR=prevalence odds ratio; p=significance. FM=forearm. SWR=Solely Work Related Cases; NWR= non work related cases.

condition as solely related to work to those reporting solely non work related conditions, disorders of the neck were twice as prevalent, and wrist disorders were five times as prevalent as corresponding disorders attributed solely to non work related causes.

Demographics and WRMSD Prevalence

Gender data (Table 4A) shows a higher number of reported neck and upper extremity disorders in females. The gender difference in self reported injury prevalence is

Table 4A. Point Prevalence, Prevalence Odds Ratio Estimates for Connecticut Neck & Upper Extremity Disorders, NIOSH Definition, Prolonged by Gender

1996 Connecticut Point Prevalence

<i>Males</i>				<i>Females</i>			
<i>Prevalence</i>	<i>n</i>	<i>P</i>	<i>SE</i>	<i>Prevalence</i>	<i>n</i>	<i>P</i>	<i>SE</i>
<i>SWR</i>	38	.023	.003	<i>SWR</i>	61	.041	.004
<i>AWR</i>	29	.018	.002	<i>AWR</i>	48	.032	.003
<i>NWR</i>	29	.018	.002	<i>NWR</i>	29	.019	.002

<i>F:M Contrast</i>	<i>POR</i>	<i>p</i>	<i>95%CI</i>	<i>Contrast</i>	<i>POR</i>	<i>p</i>	<i>95%CI</i>
<i>All Female/Male</i>	1.72	.001	1.23,2.14	<i>SWR/NWR Male</i>	1.32	.26	.79,2.21
<i>F:M-SWR</i>	1.78	.005	1.17,2.60	<i>SWR/NWR Female</i>	2.15	.001	1.35,3.45
<i>F:M-AWR</i>	1.54	.07	.94-2.51	<i>S&AWR/NWR Male</i>	2.37	.001	1.49,3.77
<i>F:M-NWR</i>	1.09	.74	.63,1.89	<i>S&AWR/NWR Female</i>	1.46	.01	1.07,1.99

Abbreviations: n=number of cases. P=point prevalence; 95%CI=95% confidence interval; POR=prevalence odds ratio; p=significance. SWR=Solely Work Related; F:M=female to male ratio. SWR=Solely Work Related; AWR= Work Aggravated; NWR= non work related cases. Point prevalence based on a sample of 1637 males,1504 females.

primarily attributable to disorders either caused by or aggravated the workplace. Male/female prevalence and prevalence odds ratio comparisons are approximately equal for non work related conditions. The examination of prevalence odds ratios within each respective gender showed relatively consistent trends, with higher proportions of work, as compared to non work related conditions.

Data for upper extremity disorders prevalence by age (Table 5A) show divergent trends for self reported work related and non work related disorders.

Table 5A. Age Cohort Point Prevalence of Prolonged Neck & Upper Extremity Disorders

Age Group	n	p	SE	UCI95%	LCI95%	POR	p	95%CI
<i>SWR</i>								
20-29	11	.021	.006	.034	.009	Reference	-	-
30-39	38	.043	.007	.056	.029	2.05	.03	1.0,4.3
40-49	27	.033	.006	.045	.020	1.55	.22	.73,3.07
50-59	16	.030	.008	.045	.016	1.45	.34	.63,3.37
60-65	4	.014	.007	.027	.000	0.65	.46	.17,2.23
<i>NWR</i>								
20-29	4	.008	.004	.015	.000	Reference		
30-39	9	.010	.003	.017	.004	1.31	.20	.37,5.07
40-49	19	.023	.005	.033	.013	3.01	.04	.96,10.5
50-59	17	.032	.008	.048	.017	4.30	.01	1.35,15.2
60-65	10	.035	.011	.056	.014	4.62	.001	1.32-17.6

Odds Ratios reference is 20-29 year age category. Abbreviations: n=number of cases, P=point prevalence; 95%CI=95% confidence interval; POR=prevalence odds ratio; p=significance. SWR=Solely Work Related Cases; NWR= non work related cases.

Work-caused disorder prevalence peaks in the 30-39 year age group, with decreases thereafter. Non work related disorders show a more regular increase with age, and highest prevalence in the oldest age groups. A stratified analysis of the age cohort prevalence of solely work related neck and upper extremity disorders by gender showed analogous trends within each gender group. The age stratified Female/Male Mantel-Haenszel weighted Odds Ratio for this analysis was 1.63 (p.02; 95%CI 1.06-2.53), not significantly different from the unstratified Odds Ratio of 1.78, suggesting an absence of significant interaction of age and gender. The overall Mantel-Haenszel age summary age standardized odds ratio for female/male differences in non work related neck and upper extremity illness was 1.15 (p=.71; 95%CI .66-1.97) indicating the absence of an overall detectable gender effect in non work related disorders.

Data were insufficient to examine trends in specific ethnic sub groups. Analysis was therefore restricted to comparing data from self designated whites, vs all other ethnic groups. This analysis shows a deficit in WRMSD injuries in non whites as compared to whites. Both groups were significantly more likely to report work related than non work related conditions, however non whites were significantly more likely to report work related problems (odds ratio 4.08, p=.02, 95%CI 1.07,18.3) than were whites (odds ratio 1.52, p=.02, 95%CI 1.07,2.16).

Variation of WRMSD risk by educational attainment was examined using 5 strata: workers with less than a high school education, those completing high school, those with some college but without a diploma from a 4 year program, those completing four years of college, and those with post graduate training. Using the lowest strata as a reference, there were not clear trends noted in WRMSD prevalence odds ratios: for solely work related disorders, the Mantel-Haenszel summary odds ratio was 0.96 (p=.94; 95%CI .59-1.56); for non work related disorders the estimate was 1.97 (p=.09; 95%CI .01-4.50). For the ratio of solely work related to solely non work related conditions, there were not significant differences except for those with high school education (odds ratio 2.53,

p=.002, 95%CI 1.33,4.86). Solely work related disorders analyzed by gender did not show significant differences at any level of educational attainment (summary Mantel-Haenszel odds ratio .91, p=.89, 95%CI .48,.91).

1996 Prevalence of Provider-Called WRMSD

Data for medical provider-called disorders is given in Table 6A. Overall, 31% of

Table 6A.. Provider-Called Diagnostic Data, NHIS-OHS Criteria Prolonged Cases, Point Prevalence

Diagnostic Group	n	P	SE	95%CI
<u>Solely Work-Related</u>				
<i>Muscle Related & Localized Pain</i> ICD9 723.0-723.9*,728.0-729.9; 781.0-781.9, 840.0-842.19	7	.002	.001	.000,.004
<i>Tendonitis & Tendon Related</i> ICD9 726.0-727.9	10	.003	.001	.001,.005
<i>Neurologic & Peripheral Nerve Disorders</i> ICD9 353.0-354.9, 333.6, 356.9, 723.4	32	.010	.002	.006,.014
<i>Arthritic, Bone & Joint Disorders</i> ICD9 710.0-722.9, 756.0-756.9, 725, 733.0-733.9	10	.003	.001	.001,.005
<u>Aggravated By Work</u>				
<i>Muscle Related & Localized Pain</i> ICD9 723.0-723.9*,728.0-729.9; 781.0-781.9, 840.0-842.19	3	.001	.001	.000,.003
<i>Tendonitis & Tendon Related</i> ICD9 726.0-727.9	6	.002	.001	.000,.004
<i>Neurologic & Peripheral Nerve Disorders</i> ICD9 353.0-354.9, 333.6, 356.9, 723.4	5	.002	.001	.000,.004
<i>Arthritic, Bone & Joint Disorders</i> ICD9 710.0-722.9, 756.0-756.9, 725, 733.0-733.9	23	.007	.001	.005,.009
<u>Non Work-Related</u>				
<i>Muscle Related & Localized Pain</i> ICD9 723.0-723.9*,728.0-729.9; 781.0-781.9, 840.0-842.19	19	.006	.001	.004,.008
<i>Tendonitis & Tendon Related</i> ICD9 726.0-727.9	22	.007	.001	.005,.009
<i>Neurologic & Peripheral Nerve Disorders</i> ICD9 353.0-354.9, 333.6, 356.9, 723.4	15	.005	.001	.003,.007
<i>Arthritic, Bone & Joint Disorders</i> ICD9 710.0-722.9, 756.0-756.9, 725, 733.0-733.9	68	.021	.003	.018,.024

Muscle Related & Localized Pain ICD9 coding excludes 723.4. Abbreviations: n=number of cases; P=point prevalence; SE=standard error; 95%CI=95% confidence interval. Analysis based on 3200 person survey.

persons with prolonged upper extremity symptoms did not seek medical attention for their conditions. Data for provider opinion as to work relatedness of the condition was available for 95% of prolonged cases who sought medical care, although cases with self reported non work related conditions were much more likely to seek medical evaluation and treatment (79.6%) than those reporting solely work related conditions (61.0%). This

difference was statistically significant (Chi2=11.76, p=.001) In the survey data for providers, the overall 1996 point prevalence of neck and upper extremity disorders was 6.9%. Providers designated 1.8% of cases as solely work related, 1.2% as work associated, and 3.9% solely non work related. The relative proportions of muscle and tendon related disorders are similar in provider called work and non work related disorders. Provider called prolonged WRMSD cases were significantly more likely to experience neurologic disorders, the great majority of which were peripheral neuropathies. Among provider called non work related cases, arthritic disorders predominated.. In the provider data the prevalence of solely work related disorders was approximately half that of solely non work related conditions. Also, the prevalence of potentially compensable conditions under Workers' compensation (either work caused or work aggravated disorders) was 3.0% as opposed to 3.9% for solely work related conditions

1996 Prevalence of WRMSD by Industry and Occupation

Crude prevalence and prevalence odds ratios for risk of self reported WRMSD were calculated for Connecticut industry sectors (Table 7A). Multivariate adjusted odds ratio estimates are also presented. These analyses are for WRMSD reported as solely work related. From the preceding stratificational analysis, a multivariate model including

Table 7A. Distribution of Prolonged WRMSD by Industry Sector. Point Prevalence

<i>Industry Sector</i>	<i>Univariate Analysis</i>				<i>Multivariate Analysis</i>							
	<i>BC</i>	<i>n</i>	<i>N</i>	<i>P</i>	<i>SE</i>	<i>POR</i>	<i>p</i>	<i>95%CI</i>	<i>β</i>	<i>SEβ</i>	<i>POR</i>	<i>p</i>
Agriculture	011-097	2	19	.105	.070	2.36	.41	.31,16.9	1.43	.758	4.18	.06
Construction	152-179	4	127	.031	.015	1.38	.59	.36,4.88	.248	.575	1.28	.67
Manufacturing	201-399	15	413	.036	.009	1.60	.25	.67,3.87	.236	.363	1.27	.52
Government	911-972	10	434	.023	.007	1.00	-	-	-.343	.404	0.71	.40
Transportation	401-497	2	117	.017	.012	0.74	.70	.11,3.64	-.538	.755	0.59	.48
Wholesale	501-519	4	107	.037	.018	1.65	.40	.43,5.85	.196	.567	1.21	.73
Retail	521-599	6	288	.021	.008	0.90	.84	.29,2.73	-.443	.481	0.64	.36
Finance/Insurance	601-679	17	319	.053	.013	2.39	.03	1.02,5.6	.622	.274	1.86	.02
Services	701-899	23	845	.027	.006	1.13	.75	.51,2.59	-.205	.325	0.82	.53

Referent for unadjusted data is Government sector. Abbreviations: BC=US. Office of Management & Budget Standard Industry Code (SIC) range; n=number of cases, N=industry group sample size; P=point prevalence; 95%CI=95% confidence interval; β=multivariate independent variable regression coefficient; SEβ=standard error of β; POR=prevalence odds ratio; p=significance.

gender, age, and their interaction effects was constructed for the analysis of industry and occupation data. The final model included gender as a main effect (odds ratio 2.21, $p=.001$, SE .225) and specific industry and occupation variables. Age variables did not reach statistical significance in any models tested (continuous, log transformed, grouped, binary coding). A variety of second order interaction terms were examined. While none was found significant, there was some evidence for an interaction effect between gender and risk in the Finance, Insurance and Real Estate sector: inclusion of an interaction term in the multivariate model rendered the main independent variables industry and gender of marginal significance. Gender adjusted industry comparisons show an excess of cases in the Finance/Insurance sector. The odds ratio, 1.86, is somewhat reduced from its univariate estimate. The agricultural sector has a marginally significantly elevated odds ratios but this estimate is based on an extremely limited sample size. Data for crude and multivariate adjusted cross sectional industry associated risks are presented in Table 8A.

Table 8A. Distribution of Prolonged WRMSD by Occupation. Point Prevalence

<i>Occupation</i>	<i>Univariate Analysis</i>				<i>Multivariate</i>						
	<i>n</i>	<i>N</i>	<i>P</i>	<i>SE</i>	<i>POR</i>	<i>p</i>	<i>95%CI</i>	β	<i>SEβ</i>	<i>POR</i>	<i>p</i>
Technical/Professional	27	969	.028	.005	1.29	.38	.55,3.10	.695	.49	2.00	.16
Manager/Administrator	12	477	.025	.007	1.16	.75	.44,3.13	.628	.538	1.87	.24
Sales Worker	6	225	.027	.011	1.23	.70	.37,1.96	.657	.612	1.93	.28
Clerical Worker	16	363	.044	.011	2.07	.09	.82,5.35	.921	.522	2.51	.08
Craftsmen	12	180	.067	.019	3.21	.01	1.19,8.7	1.32	.341	3.73	.001
Machine Operator	6	96	.063	.025	2.99	.08	.91,9.8	1.14	.446	3.14	.01
Laborers	8	170	.047	.016	2.22	.10	.74, 6.6	.829	.389	2.29	.03
Service Workers	8	367	.022	.008	1.00	-	-	.387	.576	1.47	.50

Referent for unadjusted data is Service Workers. Abbreviations: n=number of cases, N=occupation group sample size; P=point prevalence; 95%CI=95% confidence interval; β =multivariate independent variable regression coefficient; $SE\beta$ =standard error of β . POR= prevalence odds ratio; p=significance.

Gender adjusted prevalence odds ratios for specific occupations show significant increased risk of WRMSD in three manual labor occupations (craftsmen, machine operators, and manual laborers).

Discussion:

Survey Limitations:

This paper reports results from the second of two U.S. population based surveys of upper extremity WRMSD in the employed population. The current survey builds on its predecessor. While it is a state based survey more limited in size, it is broader in scope. The current survey differs in methodology, being a random digit dialing telephone interview rather than an in-person household interview survey. Telephone surveys of this type have known biases. Response rates are typically less than in in-person studies, and the overall study response rate was just under 70%. The status of non responders cannot be known with complete certainty, but there is no indication from the analysis of each of the six successive waves of respondents of a major bias that would affect study outcomes. Telephone interview surveys underrepresent ethnic distributions and lower

socioeconomic strata , and in this study, ethnicity data, reported at about half it's true population rate, was too limited to be of any real usefulness.

Self reported data has obvious limitations, and clinical and ergonomic validation of the interview instrument used in this study are being studied. The true population estimates for WRMSD in may in fact be either lower or higher than that reported here. Self reported data in the current study, however, has another level of non response bias: i.e. respondent uncertainty as to work relatedness of their condition. In this survey, some 22% of persons with prolonged neck and upper extremity pain by NHIS-OHS criteria were not able to offer an opinion as to either work, or non work relatedness of their condition. Among medical providers, only 5% could not offer an opinion as to work relatedness. Overall 31% of persons with prolonged upper extremity disorders by NHIS-OHS criteria did not seek medical attention for their conditions. For persons reporting solely work related problems, this percentage increased to 39%, while only 20.3% of respondents with non work related disorders failed to see a medical provider.

In terms of study generalizability, it is important to recognize that findings in this study can only be properly generalized to the universe of employed persons. Estimates of work and non work related morbidity were not made for persons outside the regular work force, i.e. those chronically unemployed, or those with either work related or non occupational disabling chronic conditions. Also as noted, although the NHIS-OHS case criteria for prolonged pain may be specific for WRMSD, it may lack sensitivity in the sense of excluding individuals with medically established chronic conditions originating in previous years, but not greatly symptomatic during the year actually surveyed. The present study design also allowed for only one diagnosis per respondent, whereas it is known clinically that individuals may present with more than a single diagnosis. Finally, as a cross sectional study, hypotheses may be drawn, but causal directions may not be confirmed, because of the limited temporal scope of the survey. For this reason, estimates of incidence rates from this study must be considered preliminary. Correspondingly, associations demonstrated between industry sectors and occupational titles must also be considered preliminary, as the study design sought only to characterize the job currently held, rather than work done the onset of a case's first symptoms. This latter work may be the more etiologically relevant occupation of interest.

Neck & Upper Extremity WRMSD Population Trends:

Major findings of the current report are that on a population level, neck and upper extremity symptoms are extremely common. There appears to be a preponderance of work related as opposed to non work related self reported neck and upper extremity disorders among the currently employed working age population. In the distribution of self reported WRMSD, gender appears to be a significant factor, and women appear to bear a significant burden of injury. Among non work related disorders, gender appears to be of little overall significance, despite it's well known preponderance in less prevalent systemic arthritis syndromes such as rheumatoid arthritis and collagen vascular disease. A limitation of the present report is that it did not examine the relationship of gender to workplace biomechanical injury risk factors. This data is reported separately (Warren, 1997)

In unadjusted self reported data, there appeared to be significant trends in risk of WRMSD by age, and a clear differentiation from age trends for prevalence of non work related conditions. In more detailed multivariate analysis of solely work related disorders, the effects of age were not significant when considered in relation to the influence of specific industry groups and occupations. Educational attainment, here used as a surrogate for socio-economic status, did not appear to be a strong predictor of injury risk. In the prevalence data, certain specific industries appeared to convey higher risk for WRMSD, including Insurance and Financial businesses, a major Connecticut industry sector. The data for occupational titles indicated high WRMSD prevalence specifically in manual labor workers, such as craftsmen, machine operators, and laborers.

Important differences in the proportions of solely work related disorders, as opposed to non work related disorders, were evident between worker self reports and provider-called disorders. Workers surveyed were approximately twice as likely to consider prolonged neck and upper extremity conditions as solely work related than were their providers. There was significantly better worker/medical provider agreement on the presence of non work related conditions.

For overall prolonged neck and upper extremity disorders etiologic fractions can be estimated from both self reported and provider-called data. For this estimation, direct analysis using population incidence rates is preferable to analysis using prevalence data. From self reported 1996 incidence data age adjusted to a 1995 U.S. standard, the fractions of disorders attributable to solely work related, work aggravated, and solely non work related disorders, respectively, are 51.4%, 22.6%, and 24.4%. Provider-called data, as previously described, has higher proportions of non work related diagnoses. The fractions attributable to solely work related, work aggravated, and solely non work related disorders in this data, are 32.0%, 12.0%, and 56.5% respectively. In terms of the total fraction of potentially compensable disorders under Connecticut Workers' Compensation, the proportions of combined work aggravated and work caused disorders is 75.6% for self reported injury, and 45.5% for provider-called injury. Either estimate indicates a substantial impact of the workplace on chronic neck and upper extremity disorders in the employed population.

The present population based survey of self reported and provider called neck and upper extremity WRMSD indicates overall high rates of both symptoms and NHIS-OHS defined injury. This indicates that such injuries are extremely common, and perhaps the major cause of morbidity related to neck and upper extremity disorders in the working population. Data from this survey also indicate that the potential pool of reportable, compensable injuries is quite large, and estimates that a minority (under 10%) of such injuries are treated within the current existing Workers' Compensation reporting and insurance system.

Study Aim 2: Factors Affecting WRMSD Claims Reporting to Workers' Compensation, A Preliminary Analysis

Introduction.

Population-based studies of WRMSD such as the present one have shown a significant under-reporting of cases to workers' compensation. This is in opposition to economic models of reporting, which hypothesize that workers will, if anything, over-report cases as a way to obtaining what are perceived as superior economic benefits under workers' compensation. These benefits include wage replacement for time lost from work, as well as full medical coverage without co-pays or deductibles. What is the balance of the important incentives and disincentives to reporting WRMSD to workers' compensation? This issue has not been adequately addressed in the literature to date. Systematic under-reporting of work injuries has social implications, in that the full magnitude of the human and economic problem for WRMSD will not be considered in employer decision-making, on how much to spend on prevention, in standard setting and other regulatory approaches.

A number of articles and perceptions based on "common knowledge" in the workers' compensation arena have led to a set of perceptions which lead to fundamental questioning of the validity of many work-related claims. This includes widespread public perceptions of "worker fraud" of various types, such as filing claims for non-work related injuries, complete fabrications of injuries, or, more commonly, "milking the system" in some way such as exaggerating the extent of disability or need for time off from work. These perceptions have led to the creation of fraud units within workers' compensation systems, memorable stories (frequently with videos) on news programs showing supposedly "totally disabled" workers working on the roof of their homes or similarly vigorous physical activity.

Population based studies, however, tend to show a much different picture. For example, Morse, et al (1998) found that only 10.6 % of self-reported cases of WRMSD reported their cases to workers' compensation. Fine, et. al., (1984) found 4 to 10 times more WRMSDs in two auto manufacturing plants through personal medical records than through workers' compensation reports. An unpublished, non-randomized survey of unionized workers in Manitoba in 1992 found that only 47% of those who had been told by a doctor that they had a WRMSD had filed a workers' compensation claim (Buckert and Weninger, reported by Yassi, et. al., 1996). Katz, et al. (1998) found that only 45% of 315 Carpal Tunnel Syndrome patients in Maine were receiving workers' compensation. Hensler, et. al. (1991), in a rare population-based phone interview survey of acute accidental injuries (not WRMSD), found that only 43.5% of hospitalizations were paid for by workers' compensation alone, 40.4% for outpatient visits, and 26.4% for lost work time costs.

In Connecticut, there are potential many reasons for reporting a case to the workers' compensation system. Connecticut is viewed as one of the more liberal states in terms of

benefits, although less so after extensive benefit reductions in 1991 and 1993 (Morse, 1995). Benefits include 75% of net wages (non-taxable) for lost time from work, full medical benefits with no co-pays or maximums (although choice of physician is restricted if the employer has an approved Preferred Provider Option), benefits for permanent partial disability, some retraining options if a worker is unable to ever return to the original type of work. These benefits also cover the individual if there are additional problems from the same injury/illness in the future. If a claim is not filed within one year of diagnosis for a repetitive trauma claim, then the worker gives up the right to file in the future due to a statute of limitations. In addition, there is no state disability program in Connecticut for non-work related conditions. Therefore, unless the employer happens to provide sick days or a private disability plan, there are no benefits for lost wages for non-work-related conditions.

From the literature considered generally, there are indications that reporting of workers' compensation injuries may vary with the seriousness of the condition, with regard to a workers' personal knowledge or ignorance of the local workers' compensation system, and with the paperwork ("Red Tape") burden. Additional factors may include lack of physician or other medical provider diagnosis of injury work-relatedness, reluctance to report work injuries because of concern about co-workers' negative reactions, and fear of potential reprisals on the part of employers (either in the current job or for potentially future for pre-employment screenings. Worker dishonesty has been raised by some (Durbin, 1997) as a factor in workers' compensation injury reporting. Durbin (1997) for example asserts that workers' may be more likely to file workers' compensation claims for non work related injury or when they fear lay-offs. He hypothesizes that increased workers' compensation benefits may result in higher claim amounts and an extended duration of the claims, and may encourage workers to take more risks on the job than they ordinarily would.

Other hypotheses can be derived from literature on factors associated with major disability and impairment. For example, Cheadle et al, (1994) in a study in Washington State found that longer disability was associated with the severity of the injury, older age, female gender, divorced marital status, small business settings, and higher unemployment rates in the local business area. MacKenzie, et al, 1998 found that the extent of impairment varied with age (younger workers had quicker returns to work), with education and baseline socioeconomic status, with physically demanding jobs, and with the social structure of job (factors such as social support, and especially the availability of on the job practical assistance appeared important).

Methods

This analysis is a case control study of factors influencing workers' compensation reporting, where cases were reported WRMSD, and controls were non-reported WRMSD. For WRMSD case selection, we obtained a random sample of 323 WRMSD cases selected from the Connecticut Workers' Compensation 1996 First Report of Injury database. This sample was assembled in order to provide a large number of cases who had reported their cases to enable better analysis of differences between known workers' compensation injury reporters and those cases in the general population not reporting work associated injuries to workers' compensation. The workers' compensation database case series was selected from both the Connecticut Workers' Compensation electronic database, and from paper copies of first reports that had not been entered into the database since they were not reported as involving lost time (which are the only cases required to be reported in Connecticut). All selected cases were reported in calendar year 1996. The list of selected individuals were then interviewed by CSRA using an analogous questionnaire to that previously used to interview cases in the RDD study. Response rates for the workers' compensation first report cases was considerably lower than for the RDD sample, with a 60% interview rate and a 34% overall response rate. Due to the potential bias from this low response rate, the analyses presented here were repeated using only the RDD sample (with only 31 workers' compensation cases). These results were very similar to the combined analyses including the workers' compensation first report cases, only the combined results are presented, since these analyses gave narrower confidence intervals.

The comparison (control) group of WRMSD injuries who had not reported claims to workers' compensation insurance was assembled from the Connecticut Upper-extremity Surveillance Project (CUSP) survey. As previously described, this is a random sample of working-age individuals in Connecticut identified by random-digit telephone dialing, and subsequently interviewed by telephone during the spring of 1996 (see Morse, et al, 1999 for a more complete description of the methodology). Screening questions identified individuals who had significant pain (five or more consecutive days, or 20 or more total days in the last year) in the arm, shoulder, hand, or neck that was not due to a sudden injury. All interviews were conducted by telephone by the University of Connecticut's Center for Survey Research and Analysis (CSRA).

Those with significant pain were assessed as to whether they were a likely work-related case. A work-related case (WRMSD) was defined by a positive response to at least one of the following questions:

- Was your pain or discomfort either due or made worse by work?
- Did you tell, or were told by, a medical person that this pain was work-related?
- Did the pain increase as the workday went on, as the workweek went on, or decrease when you were away from work?

There were 3,200 workers screened, which resulted in 374 people with chronic upper-extremity pain (11.7%), 292 (9.1%) with work-related conditions, and 119 (3.7%) who were “doctor-called” cases. Only 31 of the 292 cases had filed for workers’ compensation. In addition, there were 551 controls interviewed who had no chronic upper-extremity pain. The sample had somewhat fewer low income and minority workers than in the population based on census data. There was a 78% interview rate for those who were contacted, and a 66% overall response rate including non-contacts.

Statistical Methods:

Univariate comparisons were performed using standard chi-square and odds ratio analyses. Factor analysis is employed as a data reduction technique to define pertinent questionnaire constructs perceived by workers to be important for reporting WRMSD injuries. For logistic regression, forwards conditional selection of variates was employed. Statistical calculations were performed using SPSS on IBM compatible computers.

Results.

Only 31 of the 292 self reported WRMSD cases in the original RDD Connecticut Survey reported their case to workers’ compensation (10.6%, 95% CI 7.8%-12.9%); while 25 of the 119 “doctor-called” cases did (21.0%, 95% CI 15.6%-24.8%).

Univariate analysis was used to characterize the data. Table 1B shows the differences in education between WRMSD cases who filed claims and those who did not. Those who filed claims were more likely to have high school or less of education, and less likely to

Table 1B. Workers’ Compensation Claim Filing Status by Education

Educational Level	No WC Claim Filed		WC Claim Filed	
	Number	No Claim Filed (%)	Number	Filed Claim (%)
<High School	13	5.1	49	14.0
HS Graduate	82	31.9	186	53.0
Some College	67	26.1	78	22.2
College Graduate	49	19.1	23	6.6
Post Graduate	46	17.9	15	4.3
	257		351	

Chi square=74.5, p<.001

be college graduates. Table 2B examines the association of workers’ compensation claim filing with workplace unionization. This analysis shows that union membership is

positively associated with workers' compensation claims filing (OR 4.10, $p < .001$, 95%CI 2.82-6.21).

Table 2B: Union at Workplace by Filed a Claim

	No WC Claim Filed		WC Claim Filed	
	Number	No claim(%)	Number	Filed Claim (%)
Union	48	19.1	175	49.7
Non-union	203	80.9	177	50.3
	251		352	

Chi square=58.8. $p < .001$

Table 3B examines the hypothesis that work organizational climate may be associated with workers' compensation claims filing. In the analysis, WRMSD cases were significantly more likely to file workers' compensation claims in workplaces when workers' perceived lack of management support and caring in the work setting.

Table 3B: Management Concern for Workers by Filed a Claim

Perceived Management Support	No WC Claim Filed		WC Claim Filed		OR	95% CI	p
	Number	No Claim (%)	Number	Filed Claim (%)			
Mgt. Cares A Lot	61	28.4	68	19.9	1.00		
Mgt. Cares Some	70	32.6	96	28.2	1.23	0.75-2.01	0.38
Mgt. Cares Little	22	10.2	60	17.6	2.45	1.29-4.66	.003
Mgt. Doesn't Care	62	28.8	117	34.3	1.69	1.04-2.76	.03
	215		341				

Chi square=11.0, $p = .012$; (OR=Odds Ratio; 95% CI=Confidence Interval; p =p value).

The degree of worker decision latitude and autonomy at the workplace has been hypothesized to influence the probability of filing workers' compensation claims. Specifically, decreased decision latitude (in more restrictive workplaces) has been thought to be related to increased likelihood of claim filing. The univariate analysis data in this survey data set lends some support to this thesis, there being a general but somewhat inconsistent general trend in increased injury reporting with decreased decision latitude (Table 4B).

Table 4B: Easy to Leave Work Briefly by Filed a Claim

Decision Latitude	No WC Claim Filed		WC Claim Filed	OR	95% CI	p
	Number	No claim(%)				
Easy to Leave	132	53.0	144	41.4	1.00	
Somewhat Easy	54	21.7	110	31.6	1.87	1.22-2.85
Not Easy to Leave	22	8.8	38	10.9	1.58	0.86-2.93
Hard to Leave	41	16.5	56	16.1	1.25	0.76-2.05
	249		348			

Chi square=10.1, p=.018;(OR=Odds Ratio; 95% CI=Confidence Interval; p=p value).

The propensity for workers' compensation claim's filing considered by industry sector of current employment is displayed in Table 5B. Tendencies to a higher percentage of injuries reported as workers' compensation claims are found in the Manufacturing, Transportation and General Trades sectors, with a trend towards decreased workers' compensation injury claims reporting in the Agriculture, Construction and Mining and the Financial, Insurance and Real Estate Sectors.

Table 5B: Industry Sector and Claim Filing.

	No Claim Filed		Filed Claim		Total
	Cases	Percent	Cases	Percent	
Ag, Const, Mining	15	62.5%	9	37.5%	24
Manufacturing	30	14.4%	178	85.6%	208
Government	37	59.7%	25	40.3%	62
Trans/Utilities	11	40.7%	16	59.3%	27
Trade	30	41.7%	42	58.3%	72
Fin/Insur/Real Estate	32	61.5%	20	38.5%	52
Services Sector	84	57.9%	61	42.1%	145
Total	239	40.5%	351	59.5%	590

Chi-square=100.8, p<.001; n=615.

Worker Perceived Factors Influencing Worker's Compensation Claims Filing.

To better understand factors perceived by workers themselves as pertinent to the likelihood of filing a workers' compensation claim, a Factor Analysis of the questionnaire interview data was performed (Table 6B). This analysis suggested significant loadings on three primary factors: one relating to the overall severity of the injury, one characterized by fears about the consequences of reporting a workers' compensation claim, and a factor representing overall knowledge and familiarity with the workers' compensation system. In a separate analysis injury impact in terms of the degree of impairment of activities of daily living was also found to be important. The relative influence and significance of

Table 6B: Factor Analysis of Attitudes Towards Workers Compensation

	Fear	Severity	Knowledge
My Injury Was Serious		0.81	
Would Not Lose Work Time			
Claim Important For Future Problems		0.79	
Did Not Know How To File Claim (Reversed)			0.72
Afraid Of Employers Reaction	0.83		
Afraid Of Co-Workers Reaction	0.67		
Discouraged By Employer	0.63		
Had Good Knowledge Of Benefits			0.85
Afraid Of Consequences For Future Jobs	0.78		
Afraid Of Losing Job	0.86		
Alpha Levels	0.83	0.61	0.53

these factors is reviewed in Table 7B. In this analysis, the seriousness of the injury is clearly the predominant factor and significant in worker consideration of worker's compensation injury reporting. Overall impairment in ADL (activities of daily living) is also a significant but lesser factor. Worker fears about the consequences of workers' compensation injury reporting remains significant, but is seen to be a lesser factor. The general level of knowledge of the workers' compensation insurance system did not prove to be a significant factor in this analysis.

Table 7B: Relative Importance of Factor Analysis Constructs

Factor Analysis Loading	Pearson Corr.	Significance
ADL Factor	0.283	<.001
Fear Factor	0.079	0.05
Seriousness Factor	0.621	<.001
Knowledge Factor	-0.028	NS

ADL= activities of daily living.

Multivariate Analysis.

A multiple logistic regression analysis was performed for key variables affecting the overall likelihood of workers' compensation injury reporting and is presented in Table 8B. This analysis permits estimation of the effects of specific factors simultaneously adjusting for the effects of each. In this analysis, injury seriousness and workplace unionization are seen to be significant factors positively associated with workers' compensation injury claims filing, while increasing educational levels and being married are significantly negatively associated with workers' compensation injury claims.

Table 8B. Multiple Logistic Regression Analysis of Workers' Compensation Injury Reporting

Variable	Exp (B)	OR	Significance
Took Time Off Of Work	2.99	1.10	< .001
Union at Workplace	5.08	1.63	< .001
Education Level	0.62	-0.48	< .001
Married	0.58	-.55	0.031
Seriousness Factor	5.77	1.75	< .001
Initial -2 Log Likelihood	800.47984		
Final -2 Log Likelihood	447.104		
Chi-square 353.376, 5 df, significance < .001			

OR= odds ratio.

Discussion.

Limitations of the 1996 Connecticut Survey include the cross sectional nature of the study with its attendant difficulties in determining causal direction, and the possibility for recall bias. This specific case control study has additional limitations. Chief among these is the difficulty of obtaining interview data from a simple random sample of workers filing claims in the workers' compensation system. Such low response rates for workers' compensation claims samples have been problematic in other similar studies as well. Further, the design of this study did not directly address issues of worker dishonesty or malingering, felt by some to be a significant issue in the workers' compensation insurance arena.

This preliminary analysis of the 1996 Connecticut survey data regarding WRMSD workers' compensation injury reporting suggests that overall, the seriousness of the MSD injury is a predominant factor positively influencing the likelihood of a workers' compensation claim. In fact, injuries that impacted a worker's activities of daily living, or required time away from work were associated with higher injury reporting rates. The industry sector analysis shows higher prevalence of injuries reported to workers' compensation in the Manufacturing, Transportation and General Trades sectors, with a trend towards decreased workers' compensation injury claims reporting in the Agriculture, Construction and Mining and the Financial, Insurance and Real Estate Sectors. Workplace unionization is also more common in traditional manufacturing and trades industry sectors, and it is not clear from this analysis whether unionization itself, or hazards inherent in the work processes of these industries accounts for the observed increases in claims reporting. In this regard, however, it is notable that government workers, a highly unionized group, do not have significantly high workers' compensation claims rates.

Demographically, personal factors appear to play significant roles in likelihood of injury reporting. Workers' with greater personal resources, both educational and economic, but also family support, appear to report injuries less often. Unmarried individuals, and those with only a high school education or less, report significantly higher numbers of workers'

compensation claims. One possible inference that might be drawn from these findings, and the general findings in population surveys such as this one that a majority of work injuries routinely go unreported, is the conclusion that workers in general tend not to report work injuries to workers' compensation systems, and will tend to use available other available resources to address such injuries if available. Those without resources are the most likely to enter the workers' compensation system. A worker's knowledge and familiarity with the workers' compensation system initially appeared important in univariate analyses, but did not prove a significant factor in multivariate analyses.

Organizationally, factors in the work environment appear pertinent to workers' compensation claims reporting. Perceived management support for workers and a measure of the general degree of decision latitude characterizing a worker's job appear to be salient. Working in more tightly controlled settings where perceived management interest in workers is low appear to convey higher injury risk; work settings with increased employee decision latitude and high levels of perceived management support for workers appear associated with lower workers' compensation claims rates. The above findings provide some initial indications of factors that may lead workers with injuries to enter the workers' compensation system. This provides hypotheses as the basis for further, more definitive studies. Additional variables not specifically studied here may also be of interest for future studies.

Study Aim 3: The Economic & Social Burden of WRMSD

Introduction

There has been little study of the economic and social consequences of work-related musculoskeletal disorders (WRMSD) on the injured worker. Although workers' compensation is, at least theoretically, available to most workers with such disorders (with exceptions in certain jurisdictions), (1) workers' compensation does not reimburse all of the costs of an injury, nor does it address social consequences, and (2) it is thought that many cases of WRMSD, like other chronic occupational diseases, do not receive workers' compensation benefits because of lack of recognition of work-relatedness, difficulties with getting workers' compensation for occupational diseases, or other impediments to filing and/or collecting (Barth, 1980,1989; Maizlish, et. al., 1995; Tanaka, et. al., 1995; Nevitt, et. al., 1994). The actual extent of the costs of all WRMSD have previously not been carefully defined.

Studies of people who have received workers' compensation have focused on the cost of various conditions to insurers and employers. Brogmus, et. al. (1996) found that WRMSD claims for 1992 paid by Liberty Mutual Insurance averaged \$6,760 per claim, 80% higher than the average for all claims of \$3,723. WRMSD currently account for about 5% of all claims costs.

Yassi, et al. (1996) found that workers' compensation cases in Manitoba for WRMSD lost more time from work than a control group of other upper limb musculoskeletal injuries (71.4 days for WRMSD vs. 33.6 days for controls), cost more (\$5,569 vs. \$2,480), and were less likely to be able to return to the same job (67.3% vs. 81.0%). Additionally, they found that although 13% of WRMSD cases returned to modified work with the same employer, a larger percentage of cases than controls were unable to return to any work at all (2.9% vs. 0.5%). WRMSD cases were also more likely to recur upon return to work (18.9% vs. 9.6%).

Compiled anecdotal evidence has found that employers who institute ergonomic programs dramatically save workers' compensation costs, indicating that such claims are significant both in terms of costs and workplace causes. A Government Accounting Office (GAO) study of five employers found reductions of from 35% to 91% in workers' compensation costs for WRMSD, resulting from both reductions in numbers of new conditions (ranging from 2.4 to 6.1 percentage point reductions in rates), as well as better medical management and return to work programs (GAO, 1997).

However, these studies do not look at the costs that are borne by the worker and his/her family (uncompensated costs), costs covered by other employer-provided benefit systems (group health insurance, sick time, etc.), nor other externalized costs covered by government social programs, such as social security.

In addition, because these studies are based on workers' compensation data, they cannot answer the question of what happens to people who, for a variety of reasons, do not access the workers' compensation system. Fine, et. al., (1984) found 4 to 10 times more WRMSD's in two auto manufacturing plants through personal medical records than through workers' compensation reports, and an unpublished non-randomized survey of unionized workers in Manitoba in 1992 found that only 47% of those who had been told by a doctor that they had a WRMSD had filed a workers' compensation claim (Buckert and Weninger, reported by Yassi, et. al., 1996).

Studies of clinical populations have also been conducted. However, clinical studies also tend to involve biased populations, and are not representative of the full range of conditions.

A population-based approach allows a more comprehensive description of the payment sources for WRMSD. The National Health Interview Survey (NHIS) in 1988 used an occupational health supplement in an attempt to determine the extent of self-reported occupational diseases on a population basis. The survey found that 1.47% of the recently working population had self-reported carpal tunnel syndrome, and 0.53% reported that a medical provider had called their carpal tunnel syndrome work-related (Tanaka, et. al, 1995). Katz, et al (1996) showed that self-reporting (in relation to carpal tunnel) was reliable, moderately valid in relation to grip strength, and unrelated to workers' compensation status.

This project replicates the NHIS study in the Connecticut working population and extends it by examining the economic and social consequences of WRMSD to the worker. The data was gathered in a population-based cross-sectional survey and nested case-control study of the Connecticut working population (see main body of report Aim 1 discussion for further methodological details). The study compared workers with self-reported occupationally related neck, arm and hand disorders to those that did not report such disorders. This paper reports on the social and economic outcomes for the two groups.

Methods

A random sample, identified by random-digit dialing, of working-age individuals in Connecticut was interviewed by telephone during the spring of 1996. Telephone numbers were chosen in a modified stratified procedure based on the proportion of the theoretical universe residing in each residential "block" identified with the use of published directories, and based on Census figures for towns. Households were given six distinct attempts at contact before another number from the same block was substituted. Calls were made on weeknights and weekends to reduce bias. Respondents were randomized within households by asking for the working-age person in the household who had the birthday closest to the date of the interview. Screening questions identified individuals who reported significant pain (five or more consecutive days, or 20 or more total days in the last year) in the arm, shoulder, hand, or neck that was not due to sudden injury. This case definition was designed to capture chronic upper-extremity conditions, whether

work related or not, to ensure identification of individuals who might have undiagnosed work-related conditions. A subset of work-related upper extremity disorder (“WRMSD”) was then identified using the criteria below, as was a second subset using more conservative criteria (“Physician-called WRMSD”, based on self-report). These subsets (and the controls) are the focus of this paper.

A work-related case (WRMSD) was defined by a positive response to at least one of the following questions:

1. Was your pain or discomfort either due or made worse by work?
2. Did you tell the medical person your problem was work-related?
3. Did they [the medical person] say that your pain or discomfort (a) was caused by your job or (b) made worse by your job?, or
4. Did the pain increase as the workday went on, as the workweek went on, or decrease when you were away from work? (three separate questions)

To allow comparability to the National Health Interview Survey, a more conservative measure of WRMSD was also used (“**Doctor-called**”, based on self-report), which focused on only those cases that reported that a medical provider told them that the condition was caused or made worse by the job (question 4, above). Results for this group were for the most part similar to those of the WRMSD group, and so results for the “doctor-called” group are presented only where important differences appeared. Controls were defined as anyone who was not a case, with an additional exclusion of any others who reported a non-acute WRMSD (the latter included cases that did not last 5 consecutive days or 20 days over the year).

Demographics of the sample were similar to the general Connecticut population based on Census data for 1995, except for education, where the sample included a smaller proportion of with less than high school education (6% for controls, compared to 20.8 for the population of 25 years old and older), and ethnicity. This result is consistent with the use of a telephone survey, since individuals with low education are less likely to have telephones, and higher educated households are more likely to have multiple telephone lines. There was a 78 % interview response rate to the survey.

Respondents were asked about social effects of the WRMSD in three primary areas: employment, family relationships, and housing. The economic analysis looked at the source of payment for direct economic costs including medical visits and tests, and the amount of out-of-pocket expenses. Indirect costs included qualitative assessment of lost wages and benefits. Loss of productivity in the home was not specifically addressed, although some measures such as Activities of Daily Living (ADL) scales and questions about reduced work activities at home provide some qualitative information in this area. We used a prevalence-based model for costs, which framed the economic burden in a base year of prevalent cases (expenses for the last 12 months prior to interview), as opposed to incident-based costs, due to the cross-sectional nature of the survey. One inconsistency in the prevalence-based comparisons is that some medical visit questions

referred to ever having seen a doctor, as opposed to having seen a doctor in the prior 12 months.

Out-of-pocket costs were measured by asking whether there had been any costs in the past year, and for amounts for only the previous two weeks. This was designed to reduce recall bias. These costs were multiplied by 26 to give total estimated costs for the sample. This technique does not assume that the specific individual has exactly the same costs every week of the year, but rather that the previous two weeks are a random sample of the group as a whole.

Respondents were asked if they had ever had any of a number of specific medical procedures or visits. Health provider visits were broken down by the type of practitioner. "Personal doctor" was possibly a repetition of other types of doctor, and was therefore reduced by the total number of other visits (to other types of physician) reported. A walk-in medical center is one that offers treatment without appointments, and includes industrial medicine programs.

Standard statistical univariate tests were used, including chi-square tests and odds ratios with confidence intervals. Logistic regression was used to explore a model for social impacts of WRMSD. This was done using a Stepwise Backward (Conditional) removal procedure to eliminate non-significant variables. Alpha levels of less than 5% based on two-tailed tests were utilized for statistical significance. Data was evaluated using SPSS for Windows Version 7.5.1.

Results

Table 1C shows the overall sample characteristics. Altogether, 3,200 people were screened (“Screeners”) in order to find 374 people with chronic upper extremity pain. These individuals and 551 controls were interviewed by phone.

	Number	% of Sample
CT Working Population	1,520,000	
Population Sample	3,200	100%
Controls (n=598, 551 used)	551	17.2%
Chronic Upper-Exremity Pain	374	11.7%
Work-related chronic upper extremity pain (WRMSD)	292	9.1%
Doctor-called WRMSD	119	3.7%

Of the 374 respondents, 292 (9.1 % of the sampled population) were determined to be likely work-related cases (“WRMSD”) based on the four questions noted in the methods section, which includes those both *caused* by work and *made worse* by work (both would qualify as work-related under the Connecticut workers’ compensation definition). Of these 292, 119 cases (3.7 % of the overall population) reported that their medical provider had told them that the condition was caused or made worse by work (“Doctor-called” WRMSD). There had also been some cases of potential WRMSD among the controls, with 32 (5.8 %) reporting a prior case of Carpal Tunnel Syndrome, and 58 (10.5 %) tendonitis. These respondents remained as controls because they did not meet the definition of “significant” pain in the previous 12 months.

Table 2C shows case characteristics for both the WRMSD and the Doctor-called WRMSD cases based on a univariate analysis. Of the 292 cases of WRMSD, only 10.6 % (n=31) had filed a workers’ compensation claim (25, or 21.0 %, of the 119 doctor-called WRMSD had filed). Of the 31 cases who filed for workers’ compensation, 23 (74.2 %) were accepted initially by the insurer. Cases were significantly more likely than controls

	WRMSD	%	Doctor Called WRMSD
Cases	292	100.0	119
Filed for Workers' Compensation	31	10.6	25
Main wage earner in household	175	60.0	62
Cut down work pace due to WRMSD	102	34.9	56
Cut down on home activities	138	47.3	76

to report that they were the main wage earner in the household (60 % vs. 52 %, p=.023). However, fifteen (13.4 %) of the 112 cases who reported that they were not the primary wage earner said that they had been the primary prior to the injury (9, or 8.3 % of 108 for doctor-called). Over one-third of the WRMSD cases (102, or 34.9 %) reported having to

cut down on their *work pace* because of the condition (56, or 47.1 %, of the doctor-called cases). Almost half of the WRMSD cases (138, or 47.3 %) reported having to cut down activities at *home* because of the condition (76, or 63.9 %, of the doctor-called cases).

Table 3C shows social factors for the WRMSD cases compared to controls. Cases were significantly more likely to have been assigned lighter work over the past 12 months (Odds Ratio=1.6). Cases were half as likely to report being promoted in the last 12 months (OR=.45). Cases were also significantly more likely to have been divorced in the past 12 months (OR=1.91), and to have moved for financial reasons (OR=2.41),

	Cases	%	Control	%	Odds Ratio	Lower	Upper
Assigned Lighter Work	39	13.7	49	9.0	1.60	1.02	2.50
Time Off	71	25.2	179	33.3	0.68	0.49	0.93
Promoted	22	7.9	85	16.0	0.45	0.28	0.74
Early Retire	6	2.1	25	4.6	0.45	0.18	1.11
Changed Job	28	10.0	65	12.1	0.80	0.50	1.28
Stress at Home	80	28.8	127	23.6	1.31	0.95	1.82
Divorce	20	7.1	21	3.9	1.91	1.01	3.58
Move: Financial Reasons	18	6.4	15	2.8	2.41	1.20	4.86
Lose Home	9	3.1	5	0.9	3.44	1.14	10.35
Lose Car	12	4.4	10	1.9	2.45	1.04	5.74
Lose Health Insurance	18	6.6	19	3.5	1.91	0.99	3.71

* Self-report; Work-related cases (n=292) vs. Controls (n=551); CT, 1996

including more likely to have lost a home (OR=3.44) and car (OR=2.45). Losing health insurance was just below statistical significance (OR=1.91). Interestingly, even some of the *controls* that had to move for financial reasons may have been affected in part by WRMSD. Of the 15 controls who reported moving in the past 12 months, 1 reported having prior cases of tendonitis, and 2 having prior cases of Carpal Tunnel Syndrome.

Cases were significantly *less* likely than controls to report having taken time off from work over the last 12 months (OR=0.68). However, 14.7% (n=43) work-related cases indicated they had to take time off from work in the last year due to the WRMSD (21.6 %, n=63, reported taking time off ever due to the condition). Of those reporting time off in the last year, there was a total of 1,027 lost days (mean=23 days; median=4.5 days, range of 1 to 365 days). Of the cases, 7.2% (n=21) reported having to change jobs because of the condition, 4.1 % (n=12) reported losing their job due to the condition, and 4.1 % (n=12) reported having to go on disability at some point (not necessarily in the last year).

A logistical regression model was created for the dependent variable of having had any one of the non-work social factors (stress, divorce, moved for financial reasons, lose car, or lose health insurance). A significant protective effect of higher education level was found, and a nearly-significant effect of being a doctor-called case. The model removed a variable for filing a workers' compensation claim, which had been significant in the model with all work-related cases. Other variables that were dropped as non-significant were race, sex, and age. Results are presented in Table 4C.

	OR	Significance
Education	0.86	0.023
Doctor-called case	1.48	0.060
Initial -2 log likelihood	1022	
Final -2 log likelihood	1012	
Chi-Square	9.87	0.007

Cases were dramatically worse on Activities of Daily Living (ADL) scales. Table 5C shows the odds ratios for responses of "A lot" or "Some" difficulty on the measures. Odds ratios include 8.2 for difficulty in physically caring for a young child, 11.5 for difficulty opening jars, 11.8 for difficulty writing or using small objects such as keys, 11.9 for gripping a telephone, 14.3 for carrying grocery bags, 17.4 for performing household chores, 22.6 for driving, 22.7 for brushing teeth or combing hair, and 35.2 for bathing.

	Cases	%	Controls	%	OR	Lower CI	Upper CI
Writing	96	32.9%	22	4.0%	11.8	7.2	19.2
Gripping	69	23.6%	14	2.5%	11.9	6.5	21.5
Chores	135	46.2%	26	4.7%	17.4	11.0	27.4
Opening Jars	142	48.6%	42	7.6%	11.5	7.8	16.9
Child care	69	23.6%	20	3.6%	8.2	4.9	13.8
Carry Bags	139	47.6%	33	6.0%	14.3	9.4	21.7
Brushing	80	27.4%	9	1.6%	22.7	11.2	46.1
Bathing	91	31.2%	7	1.3%	35.2	16.0	77.2
Driving	113	38.7%	15	2.7%	22.6	12.8	39.7

Economic Support Other Than Workers' Compensation

Of the WRMSD, 29.1% (n=85) had received some type of economic support other than workers' compensation (45 or 37.8% of doctor-called). Of these cases, 63 (or 21.6% of the total) indicated that the benefits were needed because of the injury (35, or 29.4 for

doctor-called). These benefits are detailed in Table 6C. It should be noted that the figure for medical insurance is considerably lower than a similar question that asked about

Government Sources	N	%	Injury	%
Social Security	9	3.1	4	1.4
Unemployment	14	4.8	7	2.4
Food Stamps	4	1.4	1	0.3
Welfare	4	1.4	2	0.7
AFDC	4	1.4	1	0.3
Re-Training	4	1.4	4	1.4
Employer Sources				
Medical Insurance	51	17.5	42	14.4
Sick Time/Disability	24	8.2	17	5.8
Personal Sources				
Borrowing	8	2.7	4	1.4
Gifts	9	3.1	4	1.4
Total	131		86	
Total: Any One Benefit	85	29.1	63	21.6

N=292

medical visits and who paid (see Table 8C below). This could have occurred because this question was asked later in the survey than the questions in Table VIII, so respondents may have thought they had already answered. Controls were not asked these questions due to time limitations on the survey. There was no significant difference between cases and controls in response to the question “compared to 12 months ago, would you say your financial situation is better today, worse today, or about the same.”

Respondents with any out-of-pocket expenses in the previous 12 months were asked how much they had spent in the two weeks prior to the interview (Table 7C). In those 2 weeks, 10.6 % (n=31) of the work-related cases had out-of-pocket expenses that they attributed to their WRMSD (16.0 %, n=19 of the doctor-called). These expenses (for medical costs, transportation, equipment, child care and work around the house, etc.) averaged \$177 each, with a median of \$38 (\$238 mean and \$25 median for doctor-called). Individuals reported a range of \$1 to \$1,920. An additional 5 cases said that they had expenses, but did not know the amount.

Table 7C: Out-of-Pocket Expenses Paid, Due to Injury, WRMSD Cases only, CT, 1996							
	Doctor-Called Cases, CT, 1996, n=119				Work Related Cases, CT, 1996, n=292		
	Cases	%	Total \$	Average \$	Cases	%	Total \$
Medical	15	12.6%	3,728	249	22	7.5%	4,158
Transportation	5	4.2%	44	9	6	2.1%	245
Equipment	0	0.0%	-	-	4	1.4%	112
Child Care	2	1.7%	345	173	2	0.7%	345
House Work	1	0.8%	400	400	3	1.0%	640
Total (any one)	19	16.0%	4,517	238	31	10.6%	5,500

Twenty-eight (22) cases reported paying an average of \$189 each for medical expenses. Although the question inquired about out-of-pocket expenses, it is possible that some of these costs were eventually reimbursed.

This total can be extrapolated over the course of a year for the entire sample \$489 per case per year out-of-pocket expenses for WRMSD (31 cases X \$177 X 26= total annual cost, divided by 292 WRMSD cases. If extrapolated to the estimated 145,000 period prevalence of WRMSD in Connecticut (based on 9.6% WRMSD in a labor force of 1.52 million) this would give an estimate of \$71 million in out-of-pocket expenses per year for Connecticut alone. The 15,000 period prevalence of doctor-called WRMSD would give an estimate of \$15 million. There was no significant difference between those who filed a workers' compensation claim and those who did not on whether there were out-of-pocket costs, with about one-third of those who filed claims still having out-of-pocket costs.

Medical Visits and Procedures: Who Pays?

Respondents were asked if they had ever had visits to specific types of physicians, or specific tests done, for their WRMSD. If they did, they were asked who paid for it, and how many visits they had in the previous two weeks. The detailing of medical expenses of work-related cases suggests that a very high proportion of medical visits and procedures were paid either by general health insurance or out-of-pocket. Of the WRMSD cases, 174 (59.6 %) reported having seen a doctor for the condition. Of the total number of all the respondents with medical visits and procedures, only 21.0 % reported being paid by workers' compensation, with 70.9 % paid by general health insurance and 8.1 % paid out-of-pocket. Table 8C details these individuals with medical visits and procedures. Individuals with occupational and physical therapy were more likely to be paid under workers compensation than other treatments, with 29.6 % of individuals with visits covered. Individuals with surgical visits were also much more likely than for other

Medical Visits	n	Workers Comp	n	Health Insurance	n	Out Of Pocket	Total
Personal Doctor	5	12.2%	35	85.4%	1	2.4%	44
GP	7	10.9%	52	81.3%	5	7.8%	68
Surgeon	21	28.8%	50	68.5%	2	2.7%	75
Specialist	8	15.1%	40	75.5%	5	9.4%	55
Ot/Pt	16	29.6%	36	66.7%	2	3.7%	59
Massage	1	5.6%	12	66.7%	5	27.8%	23
Chiro	9	14.1%	44	68.8%	11	17.2%	71
Acupuncture	1	20.0%	3	60.0%	1	20.0%	8
Counselor	1	20.0%	3	60.0%	1	20.0%	6
ER	4	23.5%	11	64.7%	2	11.8%	19
Walk-In	4	25.0%	10	62.5%	2	12.5%	17
X-Ray	19	18.4%	78	75.7%	6	5.8%	108
CT/MRI	6	22.2%	20	74.1%	1	3.7%	28
EMG	11	30.6%	23	63.9%	2	5.6%	36
Medications	12	20.3%	43	72.9%	4	6.8%	64
First Surgery	10	37.0%	12	44.4%	5	18.5%	27
Second	4	40.0%	6	60.0%		0.0%	10
Third	3	75.0%	1	25.0%		0.0%	4
Total	142	21.0%	479	70.9%	55	8.1%	722

types of visits to have been paid under workers' compensation, although this still represents only 28.8 % of the individuals. In fact, subjects with WRMSD who had surgery were 3.8 times more likely to file a claim than those cases without surgery (2.23 to 13.77 confidence interval). However, even for surgical cases, 68.5 % of the respondents reported procedures that were paid for under general health insurance. This suggests a major surgical cost for WRMSD paid outside of the workers' compensation system.

More of the visits were covered by workers' compensation for the "doctor-called" WRMSD group. In this group, over 35% of individuals with surgeon's visits, and about 75% of individuals with surgeries were covered by workers' compensation.

Discussion

This study is limited by its cross-sectional design. While associations can be noted, it is often difficult to understand the directions of causality.

The study is also limited due to the self-reporting nature of the survey. Although we included the NHIS more conservative question of "Did they [medical person] say that

your pain or discomfort was caused or made worse by your job”, this is still the respondent’s perception of their medical provider’s opinion, and the medical condition was not confirmed in any independent fashion. In addition, retrospective assessments (of risks, costs, etc.) may be biased based on the respondent’s medical condition that are different between cases and controls. Attempts were made to minimize such biases through use of just the prior two weeks for costs, looking at current issues where possible, and utilizing questions used and validated in other studies. There may have been misunderstanding of some questions (such as whether questions were applying only to consequences of the condition, or apply to all expenses), or confusion about the differences between workers’ compensation and group medical insurance.

While these constraints are important, there are no other feasible alternatives to gain some understanding of the unreported cases of WRMSD (we plan on extending this study to a prospective study in the future).

The results of this population-based interviewer-administered questionnaire suggests that about 90% of likely WRMSD (79 % for doctor-called” cases) is not reported to workers’ compensation. This economic burden therefore falls on to government sources, other employer-provided benefits, and on the individual and family.

The probability of filing is considerably higher where surgery is involved, indicating that more expensive cases are more likely to be filed (although it could also be true that workers’ compensation cases are more likely to get surgery). This may be related to respondent’s with increased disability filing a claim, as indicated by a statistically significant association between filing a claim and the Activity of Daily Living scale (Pearson’s $R=.227$, $p<.001$).

In particular, a high proportion of medical bills were paid from general health insurance—71% of respondents said medical visits and procedures were paid for by general health insurance, 8 % out-of-pocket, and only 21 % from workers’ compensation. In addition, 5.8 % of WRMSD cases received benefits under sick time or disability, and 2.4 % from unemployment, attributed to the condition. This externalization of costs out of workers’ compensation is important for a number of reasons:

- Other insurance programs are less likely to cover the full costs of such conditions, adding economic pressures to disabling conditions.
- Externalizing the costs reduce employer economic incentives to prevent WRMSD, since there is typically not experience rating for other employer-provided insurance.
- Lack of reporting of such cases in traditional reporting mechanisms as workers’ compensation and OSHA/ Bureau of Labor Statistics reduces the ability to target conditions for interventions such as OSHA inspections, cluster investigations and educational efforts.

The individual economic burden this situation varies considerably. Although there was no significant difference between cases and controls on their evaluation of their financial

situation compared to a year ago, a significant minority (13%) reported that they had gone from the main wage earner in the family before the injury to not. However, this figure needs to be viewed guardedly since we do not have a comparable measure of such changes in the control group. Average out-of-pocket expenses, dominated by medical costs, were significant, averaging almost \$500 per year per case. A wide range (and lower median cost for the sample) meant that a few cases had a very large burden. When these costs are combined they lead to a significant social cost that is externalized from the insurance system. In this report, we have not analyzed the economic value of lost productivity at home in terms of activities of daily living, but did try to assess actual pay-outs for such work that could not be performed. Reported out of pocket expenses for transportation, child care, and house work due to the injury appears to affect only a small minority of cases. However, the large differences in Activities of Daily Living scores between cases and controls indicate that there are large losses in productivity in the home, and likely the work, environment.

Impact on work is complex. Despite an overall average of 3.4 lost days of injury-attributed lost days from work for all the 309 WRMSD cases, cases reported taking off *less* time overall than controls over the past year. This could mean that they felt more obligation to continue working despite their pain, or possibly a differential interpretation of the question between cases and controls.

The social impact of WRMSD also seems to affect a minority of cases, but with important individual impacts. Rates of divorce, moving and losing cars due to financial reasons, and loss of health insurance are all significantly increased. The multivariate analysis indicates that higher levels of education have a protective effect that reduces the impact of WRMSD, but the WRMSD still has an individual impact on negative social consequences.

The overall results of this survey are contrary to the position that WRMSD are over-reported. The condition is both quite common and quite disabling. Other systems such as group health insurance and out-of-pocket costs are covering a large amount of the costs of such conditions. Though overall economic consequences on the worker were not found, a small number of individual workers appear to have serious economic consequences from WRMSD: losing homes, large out-of-pocket expenses, getting divorced and facing economic insecurity. It may be an appropriate time to think of reversing the recent trend restricting eligibility for workers' compensation benefits, and to have an increased emphasis on prevention.

Study Aim 4: WRMSD Medical Care & Ergonomic Interventions in Connecticut, a Preliminary Analysis:

Introduction.

Population based estimates of the nature and extent of medical care for upper extremity WRMSD are generally unavailable. An aim of the present 1996 Connecticut survey was to develop descriptive information in this area. Specifically of interest was the type of medical care (generalist vs. specialty care, managed care vs fee for service) and its effect on WRMSD outcomes. The survey also aimed to develop population based survey data on the extent of ergonomic interventions currently performed in Connecticut businesses. This report presents results of a preliminary univariate analysis of this data.

In order to make the above assessment, data was abstracted from the 1996 randomized, population based cross sectional survey of Connecticut residents. The methodology for this survey is described in the previous report section on WRMSD Surveillance. Specific questions were asked detailing the location and type of medical care received by injured survey respondents, the type of health care plan respondents possessed, and data on the outcomes of their injuries. This allowed data from this survey to be used to examine the outcomes of patients with managed care and non-managed care plans. Questions pertinent to determining the frequency of workplace ergonomic interventions were also included in the survey

Results.

The distribution of WRMSD medical care by provider type is delineated in Table 1D. Overall, 57.3% of cases saw some kind of medical provider for their injury, while 42.7% cared for their injuries without formal medical care. From the distribution, it can be seen that the majority of patients seeing medical providers are treated by traditional allopathic medical physicians, although almost 22% of injured WRMSD patients saw Chiropractors for treatment. Non traditional therapies such as massage therapy and acupuncture were much less widely used. As noted previously, a majority of WRMSD patients were treated outside the workers' compensation insurance systems. Personal physicians and generalists provided a significant proportion of this care, however 25.5% of patients had seen an Orthopedist or Surgical specialist, and 17.3% of WRMSD patients had seen other types of medical specialists. On a population basis, medical clinics (including walk in clinics), Emergency Rooms, and Company based medical providers did not appear to play a major role in WRMSD care.

Table 1D. Medical Utilization For WRMSD Cases

Care Provider Type	Frequency	Percent
Any Medical Provider	225	57.3
Personal Physician	151	38.4
Surgeon or Orthopedist	100	25.5
Generalist, Family Practice	86	21.9
Chiropractor	84	21.4
Physical Therapist	72	18.3
Other Medical Specialist	68	17.3
Massage Therapist	28	7.1
Company Doctor	23	5.9
Emergency Room	20	5.1
Medical Clinic	18	4.6
Company Nurse	17	4.3
Acupuncturist	10	2.5
Counselor	7	1.8

WRMSD treatment outcome data is next examined. Generally, these comparisons are problematic when performed for specific provider types for the following reasons: the sample sizes available for any particular individual provider categories are limited in this survey; further, with regard to medical specialists, there is self selection of patients such that more severely injured patients typically see these providers. WRMSD treatment outcomes, however were compared using more general categories: specifically, with respect to the presence or absence of a managed care medical plan. Background data was analyzed regarding the distribution of injury severity vs. managed care coverage (Table 2D). For this analysis, more severe injuries were characterized as those having pain ratings >5 on a 0-10 analog scale, together with prolonged pain lasting more than one week continuously, or more than 20 days total during the year. This data shows only slight differences in

Table 2D. Severity of Injury vs. Managed Care Insurance Care

Insurance Coverage	Severe Pain	%	Lesser Pain	%	Total	%
Managed Care	80	64.0	45.0	36	125	50.2
Not Managed Care	48	55.8	38	44.2	86	34.5
No Insurance	14	63.6	8	36.4	22	8.8
Unknown	4	25.0	12	75.0	16	6.4
Total	146	58.6	103	41.4	249	100.0

presenting severity as a function of health insurance status Both the managed care group and the uninsured groups have very similar proportions of WRMSD cases with severe

pain status. The insured, non managed care case group has a somewhat fewer percentage of severe cases (55.8% as opposed to 64%) but this is not a significant difference (ChiSquare=.043;NS). Overall, therefore, there is not an indication that case severity significantly differs as a function of health insurance status.

Data for outcome variables was then analyzed according to health insurance status. Data for overall injury duration (length of injury) is presented in Table 3D below. It can be

Table 3D. Duration of WRMSD Injury by Health Insurance Status

Insurance Coverage	< 1 year	%	> 1 year	%
Managed Care	52	43.0	69	57.0
Not Managed Care	25	29.4	60	70.6
Not Treated	12	41.4	17	58.6
Totals	89	37.9	146	62.1

seem that privately insured, non managed care treated WRMSD patients have a somewhat larger proportion of clinical outcomes with greater than one year's duration, this despite that fact that the non managed care group has a slightly lower case mix severity than the managed care group. This difference, however, is not statistically significant, although the sample size available for the analysis is in fact somewhat limited. Cases with WRMSD injuries not seeking formal medical treatment appear to have injury durations similar to treated ones.

Impact on activities of daily living is next examined as a function of insurance status of the WRMSD health care providers (Table 4D). For the analysis, questionnaire data was used asking whether each case had had difficulty performing basic household tasks such as gripping a telephone, opening jars, or bathing and dressing. Each case was asked to rate on a scale of 1 to 4 the level of difficulty with each ADL, with 4 being the most difficulty and 1 being no difficulty at all. The answers for each question were summed and the results for people having or not having difficulty with ADL were determined by whether or not their total ADL score was equal to or greater than 24.

Table 4D. WRMSD Case ADL Outcome According to Health Insurance Status

Insurance Coverage	ADL Score >24	%	ADL Score <24	%
Managed Care	43	34.4	82	65.5
Not Managed Care	33	38.4	53	61.6
No Insurance	10	45.5	12	54.5
Unknown	4	25.0	12	75.0
Total	80	36.1	159	63.9

This analysis shows little difference among the various comparison groups in terms of ADL functioning. Having a managed care plan, private insurance, or no insurance did not seem to make a significant difference in ADL outcomes, although there was a slight, but non significant increase in adverse ADL outcomes in the uninsured case population.

Outcome in terms of overall impact on continued occupation was next examined. To determine whether or not each treated WRMSD case's injury ultimately resulted in an impact on the person's job, a variable was created aggregating information from several survey questions. If the WRMSD case had been assigned lighter work, took any time off work because of the injury, took early retirement, or permanently changed jobs because of the injury, the treated WRMSD injury was considered to have had a significant job impact. In a preliminary background analysis, it was determined that health insurance status was not significantly associated with assignment to lighter work, i.e. those WRMSD patients with managed care plans weren't significantly more likely to be assigned lighter work by their medical providers than cases with private insurance, or no insurance. Further, managed care physicians were not materially different from private physicians in terms of the frequency of utilizing diagnostic tests or x-rays. The results of the job impact analysis is given in Table 5D.

Table 5D. Impact on Job by Health Insurance Status for WRMSD Cases

Insurance Coverage	Job Affected	%	Job Not Affected	%
Managed Care	17	13.6	108	86.4
Not Managed Care	13	15.1	73	84.9
No Insurance	3	13.6	19	86.4
Unknown	2	12.5	14	87.5
Total	35	14.1	214	87.5

It can be seen from this analysis that when health insurance status is considered a primary stratifying variable, there aren't significant differences among WRMSD cases with respect to vocational outcomes. Clearly, as in previous analyses, the sample size available for study limits possible inferences.

CT Survey of Workplace Ergonomic Interventions Among CT WRMSD Cases.

Among the 292 work related or work aggravated upper extremity injury cases identified in the population survey, the population prevalence of typical workplace ergonomic interventions was delineated. These results are presented in Table 6D.

Table 6D. Prevalence of Workplace Ergonomic Interventions, CT 1996

Ergonomic Intervention	n	p	SE	POR	p	95%CI
Job Safety Evaluation	79	0.27	.03	2.77	.001	2.07-3.69
Workstation Change	69	0.24	.03	2.31	.001	1.71-3.12
Change Work Schedule	29	0.10	.02	0.82	.335	0.54-1.23
Change Equipment	59	0.20	.02	1.89	.001	1.38-2.60
Work Training Program	76	0.26	.03	2.63	.001	1.96-3.52
Health/Safety Committee	72	0.25	.03	2.15	.001	1.82-3.29

p=significance; SE=standard error;POR=prevalence odds ratio;CI=confidence interval.

In general, it can be seen that injury triggered ergonomic intervention of various types are made by employers on average in approximately 25% of upper extremities. These include job safety evaluations, workstation layout and equipment changes, worker training programs and health and safety committee evaluations. Interestingly, administrative controls such as changes in work schedules were not frequently chosen interventions on the part of employers.

To gain perspective on the overall likelihood of workplace ergonomic interventions as a result of injuries, the data for the upper extremity WRMSD cases was contrasted with the background population prevalence of non injury associated ergonomic interventions in the workplace. To perform this comparison, 500 healthy workers were surveyed for the prevalence of recent ergonomic interventions at their worksites. Prevalence odds ratios comparing the injured workers' experience with this control population (Table 7). This analysis demonstrates that injured workers were on average 2 to 2 ½ times as likely to have ergonomic interventions made at their worksite, than ordinary workers. Trends are similar to those for crude prevalences, and in the odds ratios comparisons, administrative controls failed to reach any measure of significance.

Discussion.

This population based cross sectional survey of Connecticut workers in 1996 has produced data on the extent of medical care of upper extremity repetitive strain injuries. It also has provided data on WRMSD injury outcome, given care delivered under the existing different types of health insurance. Population prevalences of the various ergonomic outcomes are also profiled in this report.

While many injured workers sought medical attention, it is pertinent that some 42.7% did not. Medical treatment in general was primarily provided by personal physicians and generalists, although surgeons, Orthopedists and medical specialists saw lesser, but substantial number of injured workers. About a quarter of workers saw alternative providers for their medical care.

WRMSD injury treatment outcomes were examined from the perspective of the type of health insurance plan. Specifically contrasted was WRMSD injury treatment under managed care plans, as opposed to injury treatment under private insurance plans. The WRMSD injury case severity presenting to these two systems was similar, and a general finding was no significant difference in outcome (managed care vs. private treatment) by a variety of measures, including duration of illness, effect on activities of daily living, or impact on the workers' job. This may not be surprising, as care appeared grossly similar for the two groups, for example the utilization of medical tests and x-rays was similar in the two insurance plans.

Finally, the prevalence of injury related worksite ergonomic interventions was examined. Injured upper extremity WRMSD cases were seen to be 2 to 2 ½ times as likely to have worksite ergonomic interventions. In general, injury triggered ergonomic

interventions occurred in approximately 25% of these cases, and included job safety evaluations, workstation layout and equipment changes, worker training programs and health and safety committee evaluations. Employers did not seem to favor administrative controls such as changes in work schedules as a preferred ergonomic intervention strategy.

This preliminary analysis has several important limitations. It is based on univariate analysis, and the effect of potential confounders such as socioeconomic status, demographics (gender, age), the effects of off-work activities, industry type and job environment, and psychosocial issues. Planned multivariate analyses may better elucidate these factors, but the sample size available may limit permissible inferences.

Study Aim 5: RSI Intervention Trial.

This study project is a randomized clinical trial, to determine the relative efficacy of conservative medical treatment for RSI in computer office workers (medical treatment only, or physical/occupational therapy), and keyboard technique retraining (an “intrinsic” ergonomic intervention aimed at changing work practices). The goal is to determine the most clinically effective and cost effective treatment strategy or combination of treatment strategies for RSI disorders. Estimates of the relative benefits, costs and complications of various strategies would be developed. Short and long term outcomes measured were performance status at work, clinical status, an psychological status.

This study project was initiated but not completed during the time period funded by grant 5 RO1 CCR112118-03. Planning for study including protocol development was carried out as originally scheduled in year one. This included development of interview instruments for baseline clinical and psychological assessment, a standardized clinical examination protocol, a physical medicine rehabilitation protocol, and a protocol for keyboard technique assessment and retraining. The clinical trial itself was scheduled to begin in study year two and conclude at the end of study year three.

Although institutional IRB approval was sought for and received, there was significant delay in obtaining final corporate permission from Travelers’ Insurance in Hartford to begin the study. Although Travelers had at the outset approved to sponsor this project and agreed to refer injured employees to the UConn clinic to participate in the clinical trial, in 1996-1997 Travelers experienced an major corporate restructuring and merger with components of Aetna Insurance in Hartford. A somewhat lengthy additional management review was necessary to give final approval for study commencement in this new business environment, and the process involved three levels of management approval: senior corporate executive management, management of Traveler’s internal workers’ compensation unit, and Travelers’ corporate risk management group. This hiatus was used to further refine and enhance the protocols for the study. In addition to the above mentioned data, an anthropomorphic data collection protocol was developed for the study to define these factor as co variates in injury risk and treatment outcomes. Further, a computerized digital image capture system and software was developed and tested to help document the computer keyboard retraining protocol data.

Final approval was obtained, however, study commencement had been significantly delayed to April 1997. The planning for patient intake and processing proved to be very successful, and the clinical evaluation and treatment protocols functioned well without any major unanticipated problems. Referrals for the study from Travelers Insurance, however were relatively slow, and despite and additional recruitment of study subjects from Aetna Insurance office workers in Hartford, at the end of the grant years funded under 5 RO1 CCR112118-03, recruitment for the study stood at 50 patients, about 1/3 of the planned overall recruitment for the study. After termination of grant funding, the study was continued using UConn Division of Occupational Medicine internal resources,

however applications for supplementary funding to continue the grant were unsuccessful, and the study was terminated in February of 1999.

Current plans are underway to complete follow up of the enrolled patients for this study and to analyze the existing data from this sample, although these results will likely not be available until the year 2000.

Additional Studies: WRMSD in Relation to Biomechanics and Work Organization

Using the 1996 CT population based WRMSD survey, an additional nested case control studies were performed: a case-control study of Ergonomic biomechanical and work organizational factors as they influence the risk of WRMSD. In this Ergonomic case control study, univariate and multivariate statistical modeling revealed a number of consistent positive associations of WRMSD risk with biomechanical exposures including: Static Postures (ORs 2.00-5.45), Repeated Pushing, Pulling, Lifting (ORs 1.86-12.75), and Repeated Neck Bending (ORs 1.07-12.8). Psychosocial and work organizational factors showing consistent positive associations were: Demands (ORs 1.26-1.59) and Organizational Support (ORs 0.53-0.79). Decision Latitude showed some associations with WRMSD risk, but not consistently across all models tested (ORs 0.30-0.49). This study has been submitted for publication and accepted. The detailed text is presented in Appendix 1.

Conclusions.

A 1996 Connecticut population based, randomized telephone interview survey of self reported, chronic WRMSD of the neck and upper extremities was performed to replicate and extend the 1988 National Health Interview Survey Occupational Health Supplement (NHIS-OHS). Nested in this survey were discrete case control studies to examine special areas of interest. Although the analysis of this data set is not yet completed, it is apparent that WRMSD in the general working population may be much more widely prevalent than previously considered. Considerable care for work related injuries takes place outside the existing workers' compensation system. The current study outlines some of the specifics of this cost shifting to private health insurance benefit plans, and to individual workers themselves. Further, the extent of medical care and preliminary data on medical outcomes are described.

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Dillon, C., Warren, N., Morse, T., Saleri, J., & Warren, A. (1998). Chronic Work Related Neck and Upper Extremity Injuries in Connecticut: A Population-Based Survey: Sample Description, Survey Methods, Incidence and Prevalence. (Submitted for publication)

Nicholas Warren, ScD, MAT, Charles Dillon, MD, PhD, MPH, Tim Morse, PhD, Charles Hall, PhD. Andrew Warren Biomechanical, Psychosocial and Organizational Risk Factors for WRMSD; Population-Based Estimates from the Connecticut Upper-Extremity accepted for publication, The Journal of Occupational Health Psychology.

Morse, T, Dillon, C., Warren, N., Factors Affecting Reporting of WRMSD to Workers' Compensation Insurance Systems (in preparation).

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Dillon, C., Warren, N, Cherniack, M., Medical Management and Ergonomic Intervention for WRMSD in computerized office workers, a pilot study. (in preparation).

Appendix 1: Biomechanical, Psychosocial & Organizational WRMSD Risk Factors

Title Page:

Biomechanical, Psychosocial and Organizational Risk Factors for WRMSD; Population-Based Estimates from the Connecticut Upper-Extremity Surveillance Project (CUSP)

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ABSTRACT

In a case-control study, nested in a population-based telephone survey of 3798 working adults, symptoms of WRMSD (Work Related Musculoskeletal Disorders) were associated with a web of biomechanical, psychosocial, and organizational factors. In several models, biomechanical exposures with strong associations were: Static Postures (ORs 2.00-5.45), Repeated Pushing, Pulling, Lifting (ORs 1.86-12.75), and Repeated Neck Bending (ORs 1.07-12.8). Psychosocial and organizational factors consistently retained in these models were: Demands (ORs 1.26-1.59) and Organizational Support (ORs 0.53-0.79). Decision Latitude entered less frequently (ORs 0.30-0.49). This research may have implications for intervention strategies. First, reducing both biomechanical and psychosocial risk may be more effective than focusing solely on engineering controls. Second, organizational culture and policy may have strong implications for WRMSD prevalence and control.

INTRODUCTION

This research explores two relatively under-addressed dimensions of the current debate concerning WRMSD (Work-Related Musculoskeletal Disorders) etiology. First, it assesses psychosocial and organizational risk factors, in combination with biomechanical risk, adding to a growing body of research in this area (for reviews, see, e.g., Bongers, de Winter, Kompier & Hildebrandt, 1993, Punnett & Bergqvist, 1997, Bernard, 1997). Second, it employs a population-based sampling methodology to estimate true incidence of these diseases and exposure-outcome associations in previously unidentified cases. The importance of this research is indicated by the extent and costs of WRMSD, the extent of undetected cases, and the relative importance of biomechanical, psychosocial and organizational risk factors.

Scope of the WRMSD problem.

The epidemic of Work-Related Musculoskeletal Disorders (WRMSD) in the United States reached formidable proportions in the last quarter of the 20th century, in terms of both human suffering and economic cost. The Bureau of Labor Statistics (1995) reported that in 1994, 32% of all lost-time injuries and illnesses resulted from "overexertion" (613,224 cases) or "repetitive motion" (92,576 cases). 15 years ago NIOSH termed occupationally related musculoskeletal disorders one of the five leading categories of occupational diseases and injuries (Centers for Disease Control, 1983). NIOSH (1996) has emphasized the importance of WRMSD in the National Occupational Health Agenda (NORA), noting that these diseases represented nearly 65% of all illness cases in the BLS annual survey in 1994. Although WRMSD still constitutes the most frequently reported category of work-related illness, reported cases have declined over the last two years. While this is encouraging to practitioners, indicating that increased recognition and prevention efforts are having an effect, our research suggests that expanded attention to psychosocial and organizational factors might improve intervention strategies.

Accurate cost estimates of upper-extremity WRMSD are important in justifying the costs of research and intervention. But even within the insurance industry, little comprehensive information on the true costs of WRMSD is available. An early study by NIOSH, looking at 1979 data reported to the U.S. Dept. of Labor, found that about 6% of Workers' Compensation claims in 30 states were cumulative trauma injuries to the wrist, with an average cost to settle a claim of \$1,498 (Jensen, Klein, & Sanderson, 1983). Webster and Snook (1994) analyzed the Workers' Compensation costs paid by one insurer in 1989. They found that upper extremity cumulative trauma disorders represented 0.83% of all claims and 1.64% of all claims costs. The mean cost per case was \$8,070 (as compared to a mean of \$4,075 for the average Workers' Compensation claim); the median cost was \$824 (compared to \$168). They estimated total compensable costs for upper extremity cumulative trauma disorders in the U.S. at over \$500 million. More recently, Hashemi, Webster, Clancy, & Courtney (1998) found highly skewed costs, with a few claims comprising a large percentage of overall costs and disability and 60% of the claims costing \$1,000 or less. Brogmus and Marko (1996) found that WRMSD claims for 1992 paid by Liberty Mutual averaged \$6,760 per claim, 80% higher than the average for all claims of \$3,723 and that WRMSD currently accounts for about 5% of all claims costs.

Such projections represent only the direct costs (medical and indemnity) paid for identified cases by the insurer. They do not include costs for undiagnosed or reported but uncompensated cases. Fine, Silverstein, Armstrong, & Anderson (1986) found four to ten times more WRMSD in two auto manufacturing plants through personnel medical records than through Workers' Compensation reports. An unpublished survey of unionized workers in Manitoba in 1992 found that only 47% of those who had been told by a doctor that they had a WRMSD had filed a Workers' Compensation claim (Buckert & Weninger, reported by Yassi, Sprout, & Tate, 1996). Virtually no studies address outcomes of these unreported cases of WRMSD (Moore, 1992).

Extent of Undetected Cases

Two sources of data from Connecticut provide a rough estimate of WRMSD cases that are not captured by existing reporting systems. Morse (1996) compared the 1995 data from the Workers' Compensation System to the physicians' reports that are the basis of the Connecticut surveillance system. Of the 661 lost-time cases of arm and hand disorders identified through Workers' Compensation and the 793 identified through physicians' reports, only 52 appeared in both systems. Capture-recapture analysis $[(661*793)/52]$ gives a total of approximately 8700 cases not captured by either system and a total of

10,000 (661 + 793 + 8700) new cases per year. These figures suggest that more than 85% of WRMSD cases are undetected.

Self-reports of symptom onset in the population survey from which our data are drawn (below) allow calculation of a WRMSD incidence rate for 1996 (Dillon, Warren, Morse, Saleri, & Warren, 1998) of 28.6 per thousand. The Connecticut work force numbers approximately 1.5 million, with 43,000 new WRMSD cases annually. Part of the reason for the difference in magnitude is that the population survey includes neck problems, while the other two data sources above include only arm and hand disorders. But these figures support the conclusion that a large percentage of WRMSD incident cases in Connecticut are not reported. These statistics indicate the importance of capturing unreported cases in studies of WRMSD etiology.

Psychosocial and Organizational Risk

Although researchers have made great strides in detailing associations between risk factor exposure and the development of WRMSD (e.g., Kourinka & Forcier, 1995, Bernard, ed., 1997), the natural history of these disorders is still imperfectly understood. There is controversy over whether the increase in WRMSD (until recently) is attributable to an actual increase in underlying risks, better recognition and reporting, changes in Workers' Compensation structure, and/or other variables such as cultural and social factors (Putz-Anderson, 1991, Kourinka & Fourcier, 1995). It seems reasonable to hypothesize that at least some of the increase is related to risk increases, with risk being defined more broadly than biomechanical stressors, alone. NIOSH has explicitly included in its documents on national strategies for prevention of musculoskeletal injuries (NIOSH, 1991, 1996, Chaffin & Fine, 1992) the inclusion of psychosocial risk assessment and the multilevel examination of organizational characteristics in studying the etiology of WRMSD.

The associations between psychosocial stressors and heart disease have been well-characterized (Karasek, 1979, Karasek & Theorell, 1990, Johnson, Hall, & Theorell, 1989, Johnson, Hall, Stewart, & Theorell, 1993). But the study of the associations between psychosocial risk factors and WRMSD is relatively new. Bergqvist, Wolgast, Nilsson, Voss, (1995) found task flexibility and peer contacts to be associated with a number of upper extremity diagnoses. A 10 year prospective study in Finland (Leino & Hänninen, 1995) is demonstrating that social support and work content measures predict changes in upper extremity, lower back and lower limb disorders over the 10 year period. Bongers, de Winter, Kompier, & Hildebrandt, of the Dutch TNO, prepared a review of the epidemiological literature in 1993. This review of 29 studies that directly addressed work characteristics suggests that monotonous work, high perceived work load, time pressure, low control and lack of social support are related to musculoskeletal outcomes. (The Bongers et al. study also pointed out that joint collection of data on psychosocial and physical risk factors is relatively rare.) Punnett and Bergqvist (1997) review a large international body of literature linking psychosocial factors to upper extremity symptoms and findings in computer users.

In the United States, Faucett and Rempel (1994) found that musculoskeletal symptoms in VDT workers were the result of a complex interaction between work posture, psychological demands, decision latitude, and employee relationship with the supervisor. Two NIOSH studies, at the L.A. Times (Bernard, Sauter, Petersen, Fine, & Hales, 1992) and U.S. West Communications (Hales et al., 1992) found a relationship between psychosocial stressors and the development of musculoskeletal symptoms among VDT workers (see also summaries and a 3rd study in Hurrell, Bernard, Hales, Sauter & Hoekstra, 1996). Warren's (1997) analysis of the Monitor data base from the Netherlands (see below), has demonstrated that psychosocial and biomechanical exposure variables have separate main associations and mild interactive associations with outcomes of musculoskeletal strain, pain, long-term sick leave, and partial disability. Amick, Kawachi, Coakley, Lerner, Levine, Colditz (1998), in a cross-sectional analysis of the nurses' health study cohort, demonstrated a relationship between physical function and pain reports and the JCQ constructs of Psychological Demands, Decision Latitude, and Social Support (operationalized as job strain and iso-strain). Moon & Sauter, 1996. Contains a collection of papers summarizing the state of the art in this field, with respect to office work.

Work is also just beginning on characterizing the importance of organization-level risk factors. Shannon, Mayr, & Haines (1995) found management safety commitment to be a strong negative predictor of accident rates. Pransky, Snyder & Himmelstein (1996) focus on 6 aspects of "organizational response" that have impacts on the prevention and management of WRMSD. Houtman, Goudswaard, Dhondt, van

der Grinten, Hildebrandt, & van der Poel (1997) have shown in a large national survey, the Monitor Study (Houtman ILD, Goudswaard A, Dhondt S, van der Grinten M, Hildebrandt VH, & Kompier, 1994), that employer and employee perceptions of risks in the company are poorly correlated. Warren's (1997) analysis of this database found that difference between employee and employer risk reports were associated with increased levels of shop floor stressors for WRMSD. Research on a construct termed Perceived Organizational Support (POS) suggests that worker stress, satisfaction, and other measures are related to perceptions of support at the company level (Eisenberger, Huntington, Hutchison, & Sowa, 1986. Eisenberger, Fasolo, & Davis-LaMastro. 1990, Jones, Flynn, & Kelloway, 1995).

Value of the Population-Based Approach

With the exception of the CTS questions contained in the 1988 NHIS (National Health Interview Survey, Tanaka, Wild, Seligman, Behrens, Cameron, & Putz-Anderson, 1994, Tanaka, Wild, Seligman, Halperin, Behrens, & Putz-Anderson, 1995), no large study has attempted to systematically characterize the prevalence and incidence of WRMSD in the United States' working population. The NHIS did not collect extensive exposure information (although its door-to-door interview design has advantages over the UConn. telephone survey). There are several important reasons for performing this time consuming population survey. It is the most efficient way of identifying unreported WRMSD cases. The methodology provides the least biased estimates of exposure prevalence and distribution, symptom prevalence, and the associations between them. This information is valuable for generalizing to larger populations and also provides the basis for prioritizing, guiding and evaluating intervention strategies.

METHODOLOGY

Sample Population

Dillon et al. (1998) describe the details of the UConn. questionnaire construction, random sample selection and telephone survey administration. From May, 1995 through March, 1996 the Roper Center for Public Inquiry at the University of Connecticut sampled 3200 respondents in the state of Connecticut by random-digit dialing. Overall response rate was 68%; wave analysis of respondents (comparing individuals reached on the first call to those reached on successive calls) suggests that individuals who were hard to reach were not different from those reached on the first phone call, except in sex distribution (Dillon, et al., 1998). All 3200 received a short (± 5 minutes) screening interview, assessing type of work, primarily biomechanical exposures, and broad symptom status, to identify cases. Respondents were identified as cases if they reported upper extremity pain or discomfort in the last 12 months, not due to an injury, that had lasted more than one week or had been present for more than 20 days out of the year (NHIS definition; Tanaka et al., 1994). The 374 identified cases then received a more detailed ($\pm 1/2$ hour) case questionnaire. This questionnaire assessed symptom and exposure status in greater detail, including biomechanical, psychosocial and organizational risk factors. Respondents also answered an array of questions designed to examine the social and economic costs of WRMSD to injured workers (Morse, Dillon, Warren, Levenstein, & Warren, 1998). The questionnaire identified 292 work-related cases, based on respondents' reports that the pain or discomfort a) was due to or made worse by work, or b) increased over the workday or work week, or c) decreased while away from work.

An additional set of 598 controls were sampled by telephone with a detailed interview that paralleled the case questionnaire; 553 passed our final control definition: no upper extremity pain in the last 12 months, or pain that was solely due to traumatic injury. The research reported in this paper concentrates solely on the 292 work-related cases and 553 controls.

Interview Instrument

The screening interview and longer case and control interviews were constructed as much as possible from existing validated instruments. Biomechanical exposures were assessed using upper extremity checklist questions from the 1995 OSHA draft ergonomic standard (OSHA, 1995), adapted for self-report administration. Respondents were asked to estimate the number of hours in an average day that they were exposed to each risk factor (see Appendix I). Psychosocial exposures were assessed by a reduced set of questions from the Job Content Questionnaire (Karasek, Pieper, & Schwartz, 1985). Landsbergis, Schnall, Pickering, Warren, & Schwartz (1996) have found this reduced set to be most predictive of blood pressure variance in a diverse sample of workers. We included several items from the Dutch Monitor questionnaire that we hypothesize measure organizational factors (Houtman et al., 1994). The single item, "Is your work mentally stressful", was identified by Hodgson, Olesen, & Callopy (1997) as correlating well with summary JCQ scores in research on sick building syndrome.

The high cost of the population sampling required this extremely limited set of measures. Limitations of this item selection are noted in the Discussion. All psychosocial and organizational questions not assessed in the hourly format were quantified on a 4-step Likert scale: strongly disagree", "somewhat disagree", "somewhat agree", "strongly agree". This scheme is well validated in the work organization literature (Karasek et al., 1985, Karasek, Theorell, Schwartz, Schnall, Pieper, & Michela, 1988, Karasek & Theorell, 1990, Houtman et al., 1994). Pain/discomfort locations and symptoms were assessed with questions drawn from the Standardized Nordic Questionnaires (Kourinka, Jonsson, Kilbom, Vinterberg, Biering-Sørensen, Andersson, & Jørgensen, 1987). Type of work and type of business questions used standard U.S. census categories. Years in This Type of Work were assessed for the job in which symptoms appeared. Appendices I and II list the questions used in the present case-control analysis.

Data Reduction

Exposure to all biomechanical risks and two psychosocially relevant risks (Mentally Stressful Work and Machine-Paced Work) were assessed as "hours per day" (see Appendix I for items). The distribution of these reports was highly non-normal, with large peaks at 0 and 8 hours and a tail out to 12 hours (the cutoff for analysis). This non-normality probably contributed to the lack of reliable factors that emerged from factor analysis (Norusis/SPSS, 1994b). Factor analysis did identify two loose sets of these variables, one related to fine motor and computer work, the other relating to larger body motions/postures. These were not entered as factors but formed the basis for creating two separate blocks in the Forward entry procedure

described below. We assessed possible collinearity by entering all factors simultaneously as independent variables in a test logistic regression model with case-control status as the dependent variable. Analysis of the $\hat{\beta}$ correlation matrix showed there was not enough collinearity among this predictor set to destabilize the modeling (no correlations $> .40$ and most well below $.10$, absolute value).

All the psychosocial and organizational items assessed by the 4-part Likert scale showed a distribution somewhat skewed to the left (tail towards “strongly disagree”). Given the robustness of logistic regression, particularly with respect to non-normality in the independent variables, this non-normality was judged acceptable (calculated skew measures range from $-.493$ to -1.25 , and kurtosis measures were slightly platykurtotic, ranging from $-.107$ to -1.51). Factor analysis generated 4 stable factors: Decision Latitude, Co-Worker Support, Supervisor Support, and Assessed Organizational Support (see Appendix II for items and scale reliability). The last label is used to separate this construct from the more detailed Perceived Organizational Support scale developed by Eisenberger et al., 1986. This scale consists of 3 items that we hypothesize are measures of organizational policy and culture, as viewed by employees. The Demand axis of the Demand-Control-Support model (Karasek & Theorell, 1990, Johnson & Hall, 1988) was assessed with one item: “Work Very Hard”, an item which is unfortunately quite ambiguous in its reference to psychological or physical demands.

Analysis Plan

The analysis used case status (control = 0; case = 1) as the dependent variable in logistic models. Univariate relationships were studied first. After the initial multivariate analysis in the entire work-related case (292) and control (553) population (total $n = 845$), we stratified multivariate modeling by several sub-analyses. The N for each analysis appears in the tables.

1. Separation of cases and controls by gender.
2. Separation of cases into those with distal presentation (pain/discomfort in thumb, fingers, hands, wrists, forearms or elbow) and proximal presentation (shoulder/upper arm, neck), each group compared to the full set of controls.
3. Separation of cases into 3 tissue pathology groups: musculo-tendonous, neurological, and joint/arthritis, each group compared to the full set of controls.
4. Separation of cases and controls into three large occupational sub-groups:
 - a. Professional & Managerial (including technical and administrative)
 - b. Service and Clerical (service, clerical and sales)
 - c. Manual Labor (craftsmen, machinery operators, transportation, laborers, farmers)

Statistical Approach

All logistic regressions use the Forward, Likelihood Ratio procedure (Norusis/SPSS, 1994a). Probability for entry is $.05$; probability for removal is 1.0 . We report reduction in -2 Log Likelihood as a measure of each model’s ability to distinguish cases from controls. A final significance level for retained variables of $.05$ is used as the cut-off for statistical significance, but levels between $.05$ and 1.0 are reported, to show near-significance. We report significance levels greater than 1.0 (with the numbers in *Italics*) in two situations: the univariate regressions (Table 1) and any of the four control variables excluded by the regression procedure (to show that confounding by these measures is unlikely). These items are not reflected in the degrees of freedom reported at the bottom of the tables.

Because of the non-normal predictor distributions, we performed univariate non-parametric tests (Mann-Whitney U) on all the variables collected as “hours per day” and compared these to univariate logistic regressions on these variables. We performed these comparisons with the predictors dichotomized at 0 hours/ >0 hours as well as in their original interval form. The comparison showed that the significance of the tests was virtually unaffected by the choice of parametric or non-parametric methods. This indicates that we could run the parametric regressions with the interval or dichotomized variables and get reliable estimates of effect. Logistic regression tests are more familiar and more easily interpretable; most importantly, they allow estimates of effect for each predictor, adjusting for levels of the other predictors in the model. Finally, non-parametric methods have less predictive power. Given the limited sample size, we needed all the predictive power possible.

For these analyses, we chose to use the dichotomized variables, for several reasons. First, this is a simple way to address the non-normality of these variables (although, theoretically, even non-normal distributions of the independent variables will result in unbiased estimates, assuming no error in

measurement). Second, the dichotomized variables somewhat address the problem of outliers in small cells. A third reason to use dichotomized variables is the contention of some researchers that self-reports of exposure in anything more complicated than dichotomous form dramatically decreases reliability (e.g., Wiktorin, et al., 1993). We will use the interval, hourly data to generate empirically derived cut points for each variable to be used in future work with this questionnaire.

The logistic models use successive forward entry of 5 blocks; Appendix I shows details of block composition. Since the saturated test model revealed no serious multi-collinearity, the simultaneous entry of any variable group was possible without de-stabilizing the models. In practice, only a few variables were retained from any one block.

Hypotheses of the Research

Because this is a cross-sectional study, it is intended to generate hypotheses for further testing in planned longitudinal studies. The following hypotheses are presented as associations, because causal connections cannot be definitively established from the present research.

1. Exposure to well-established biomechanical risk factors is associated with WRMSD case status in this population sample.
2. Exposure to psychosocial risk factors is independently associated with WRMSD case status.
3. Perception of organizational support is associated with reduced WRMSD case status.
4. Length of occupational exposure is associated with WRMSD case status.
5. Psychosocial exposures are more strongly associated with proximal cases than distal (due to location of psychosocially induced muscle tension).
6. Psychosocial exposures are most strongly associated with musculo-tendonous disorders, as compared to neurological and joint/arthritis.
7. Psychosocial exposures explain a greater proportion of variance in the professional/managerial job group, because the biomechanical exposures are of lower intensity.

RESULTS

In all the following tables, the same set of independent variables appears in the left column, for comparability. The analysis began with univariate models, controlled for gender, education level, age and years on the job.

Table 1:
Univariate Odds Ratios. Outcome Variable: Case Status
N = 885 (292 work-related cases, 553 controls)

Independent Variables	OR	Confidence Interval		Sig.
		Low	High	
<u>Control Variables</u>				
Gender	1.42	1.06	1.90	.017
Education Level	<u>0.94</u>	<u>0.84</u>	<u>1.06</u>	<u>.328</u>
Age	<u>1.00</u>	<u>0.99</u>	<u>1.01</u>	<u>.621</u>
Years at Work where Injury Occurred	1.02	1.01	1.04	.004
<u>Psychosocial/Organizational</u>				
Decision Latitude	0.68	0.54	0.86	.001
Co-Worker Support	0.78	0.63	0.94	.023
Supervisor Support	0.65	0.55	0.77	.000
Assessed Organizational Support	0.67	0.57	0.78	.000
Work Very Hard	1.41	1.17	1.70	.000
Assembly Line/Machine Paced Work	1.68	0.95	2.99	.076
Work Mentally Stressful	1.56	1.11	2.19	.011
<u>Biomechanical: Hours per Day</u>				
Unsupported Hand Work	<u>1.07</u>	<u>0.79</u>	<u>1.45</u>	<u>.670</u>
Pinch Grip	1.83	1.35	2.50	.000
Hard Whole Hand Grip	2.14	1.59	2.88	.000
Repeated Neck Bending	3.09	2.25	4.25	.000
Working in Cold Temperatures	1.88	1.32	2.68	.001
Repetitive, Strenuous Push, Pull, Lift	1.98	1.49	2.65	.000
Repetitive Reaching above Chest Height	1.55	1.16	2.06	.003
Repetitive Wrist Bend	1.99	1.46	2.73	.000
Vibrating Tools or Machinery	1.62	1.15	2.29	.006
Repetitive Hand Motion (\leq Every 15 sec.)	2.42	1.59	3.67	.000
Working at a Computer Keyboard	0.78	0.58	1.04	.086
Static Postures	2.68	1.99	3.60	.000

Variable units used in all tables: See Appendix I

In the univariate analyses of the entire case/control set, only 2 demographic variables attain significance: Years at this type of work and Gender. Education level is generally not significantly protective in this population. Age does not enter significantly in any model.

Decision Latitude and all three forms of Support and show similar levels of protective association in the univariate models, with Co-Worker Support being least predictive. The single Demands item ("Work Very Hard") and the general measure of Mentally Stressful Work are positively associated with case status. The near-significance and wider confidence interval of exposure to Assembly Line/Machine Paced Work reflects the very low prevalence of this risk factor in the population; only 6 % reported any exposure.

Presence of biomechanical risk factors is significantly associated with case status in all but 2 items, with 3 Odds Ratios being well above 2.0: Repeated Neck Bending, Repetitive Hand Motions and Static Postures. Unsupported Hand Work, present in 42.8% of the sample, shows no differential distribution in cases and controls. The same lack of differentiation appears for Working at a Computer Keyboard. Some of these items never achieved statistical significance in any of the multivariate models. Other research, however (Bernard, Ed., 1997) strongly suggests that in specific working populations these items could explain some portion of variance. We entered the full set of variables in all multivariate models, to explore their possible entry in specific sub-analyses.

Table 2:
Multivariate Logistic Regression; Full Model. Outcome Variable: Case Status
N = 845 (292 work-related cases, 553 controls)
(Variables assessed as "Hours Worked" are dichotomous variables, 0/>0 hrs.)

Independent Variables	Odds Ratio	Confidence Interval		Sig.
	OR	Low	High	
<u>Control Variables</u>				
Gender	1.66	1.13	2.45	.010
Education Level	<u>0.91</u>	<u>0.78</u>	<u>1.04</u>	<u>.173</u>
Age	<u>1.00</u>	<u>1.00</u>	<u>1.00</u>	<u>.616</u>
Years at Work where Injury Occurred	1.03	1.01	1.05	.004
<u>Psychosocial/Organizational</u>				
Decision Latitude	0.64	0.45	0.91	.013
Co-Worker Support				
Supervisor Support				
Assessed Organizational Support	0.76	0.60	0.94	.015
Work Very Hard	1.40	1.10	1.79	.007
Assembly Line/Machine Paced Work				
Work Mentally Stressful	1.69	1.03	2.78	.038
<u>Biomechanical: Hours per Day</u>				
Unsupported Hand Work				
Pinch Grip				
Hard Whole Hand Grip				
Repeated Neck Bending	1.89	1.24	2.86	.003
Working in Cold Temperatures				
Repetitive, Strenuous Push, Pull, Lift	2.13	1.43	3.17	.000
Repetitive Reaching above Chest Height				
Repetitive Wrist Bend				
Vibrating Tools or Machinery				
Repetitive Hand Motion (\leq Every 15 sec.)	2.04	1.12	3.71	.020
Working at a Computer Keyboard				
Static Postures	1.96	1.33	2.89	.001
Initial -2 Log Likelihood 792.0 Final -2 Log Likelihood 669.0 Model Improvement 123.0 10 df; p = .000				

Table 2 shows a smaller number of variables capturing most of the variance in the multivariate model for the full case/control sample. The demographic variables of gender and Years at this Type of Work retain their significant entry. Even in the multivariate model, in which gender-based differences in exposure are somewhat controlled, the OR for gender is actually elevated, from 1.42 in the univariate model to 1.66 in the full model, indicating its increased importance when adjusted for levels of the other independent variables.

In this model, 4 items have significant entries in the Psychosocial block: the Demands variable (Work Very Hard), Decision Latitude, Assessed Organizational Support and the summary measure, Mentally Stressful Work. Work Very Hard is an ambiguous measure of Demands, having both a physical and a psychological demands interpretation. In most of the subsequent models, Organizational Support appears to capture most of the variance that was measured for the other support variables in the univariate models; it shows the most consistent protective relationship.

Finally, the relationships suggested by the univariate models continue in the biomechanical exposures. Repeated Neck Bending, Repeated Push/Pull/Lift, Repetitive Hand Motion and Static Postures have levels of association that are roughly similar to each other.

Table 3:
Logistic Regression Stratified by Gender
Outcome Variable: Case Status

Independent Variables	Females N = 470 (178 case/292 control)				Males N = 373 (112 case/261 control)			
	O.R.	C.I.		Sig.	O.R.	C.I.		Sig.
		Low	High			Low	High	
<u>Control Variables</u>								
Gender	--	--	--	--	--	--	--	--
Education Level	<u>0.87</u>	<u>0.72</u>	<u>1.06</u>	<u>.172</u>	<u>0.95</u>	<u>0.76</u>	<u>1.18</u>	<u>.641</u>
Age	<u>1.00</u>	<u>1.00</u>	<u>1.00</u>	<u>.620</u>	<u>1.00</u>	<u>1.97</u>	<u>1.03</u>	<u>.929</u>
Years at Work	<u>1.02</u>	<u>1.99</u>	<u>1.05</u>	<u>.126</u>	1.04	0.01	0.07	.013
<u>Psychosocial/Organizational</u>								
Decision Latitude	0.49	0.31	0.79	.003				
Co-Worker Support								
Supervisor Support					0.70	0.48	1.01	.056
Assessed Org. Support					0.67	0.46	0.97	.032
Work Very Hard	1.36	0.98	1.90	.067	1.51	1.04	2.21	.032
Machine Paced Work								
Work Mentally Stressful	1.96	1.04	3.70	.037				
<u>Biomechanical: Hours/Day</u>								
Unsupported Hand Work								
Pinch Grip								
Hard Whole Hand Grip								
Repeated Neck Bending	2.03	1.20	3.46	.009	2.35	1.28	4.53	.011
Working in Cold Temp.								
Repetitive Push, Pull, Lift	2.21	1.31	3.70	.003	1.98	1.07	3.67	.031
Reaching above Chest								
Repetitive Wrist Bend								
Vibrating Tools/Machinery								
Repetitive Hand Motion	2.24	1.01	4.94	.046				
Computer Keyboard								
Static Postures	2.45	1.47	4.09	.001				
	Initial -2 Log Likelihood 454.7 Final -2 Log Likelihood 381.5 Model Improvement 73.2 7 df; p = .000				Initial -2 Log Likelihood 333.2 Final -2 Log Likelihood 281.2 Model Improvement 52.0 6 df; p = .000			

None of the control variables enter significantly in these models, except Years at Work in the male population. In both models, Work Very Hard is predictive, but while increased Decision Latitude is protective for women, a combination of Organizational and Supervisor Support are protective for men. Mentally Stressful Work is predictive only in the female model. The same set of biomechanical exposures that explained variance in the full population also enters in the female model. The ORs are similar, with the exception of Static Postures, which demonstrates a higher OR (2.45 vs. 1.96) when males are removed from the modeling. In the male model, Repeated Neck Bending and Repetitive Push/Pull/Lift enter at roughly the same effect size, but neither Repetitive Hand Motion nor Static Postures achieves significance.

Table 4:
 Logistic Regression Stratified by Distal or Proximal WRMSD
 Outcome Variable: Case Status. Cases compared to 553 controls

Independent Variables	Distal WRMSD N = 701 (148 cases)				Proximal WRMSD N = 694 (141 cases)			
	O.R.	C.I.		Sig.	O.R.	C.I.		Sig.
		Low	High			Low	High	
<u>Control Variables</u>								
Gender	<u>1.31</u>	<u>0.84</u>	<u>2.05</u>	<u>.231</u>	1.82	1.12	2.96	.016
Education Level	<u>0.82</u>	<u>0.66</u>	<u>1.02</u>	<u>.070</u>	<u>1.03</u>	<u>1.85</u>	<u>1.24</u>	<u>.772</u>
Age	<u>1.00</u>	<u>1.00</u>	<u>1.00</u>	<u>.739</u>	<u>1.00</u>	<u>1.00</u>	<u>1.00</u>	<u>.695</u>
Years at Work	1.03	1.01	1.05	.022	<u>1.02</u>	<u>1.00</u>	<u>1.04</u>	<u>.118</u>
<u>Psychosocial/Organizational</u>								
Decision Latitude								
Co-Worker Support								
Supervisor Support					0.78	0.59	1.04	.092
Assessed Organizational Support	0.70	0.54	0.92	.010				
Work Very Hard	1.55	1.12	2.15	.009	1.33	0.98	1.81	.063
Machine Paced Work								
Work Mentally Stressful								
<u>Biomechanical: Hours/Day</u>								
Unsupported Hand Work								
Pinch Grip								
Hard Whole Hand Grip	2.97	1.76	5.00	.000				
Repeated Neck Bending					2.22	1.31	3.78	.003
Working in Cold Temp.								
Repetitive Push, Pull, Lift					1.86	1.14	3.05	.013
Reaching above Chest								
Repetitive Wrist Bend								
Vibrating Tools/Machinery								
Repetitive Hand Motion	3.35	1.28	8.75	.014				
Computer Keyboard								
Static Postures	2.08	1.28	3.38	.003	2.10	1.29	3.43	.003
	Initial -2 Log Likelihood 524.6 Final -2 Log Likelihood 436.9 Model Improvement 87.7 7 df; p = .000				Initial -2 Log Likelihood 507.9 Final -2 Log Likelihood 447.8 Model Improvement 60.1 6 df; p = .000			

Table 4 shows the models stratified by location of injury. In each model, the case stratum (distal or proximal injury) was compared to the full set of controls. The differences in control entries are intriguing. For proximal presentations, only Gender has a positive relationship with case status, while for distal presentations, Years at this Work is the important variable (with a near-significant effect of Education Level). It is not immediately obvious why distal injury would be a function of exposure duration, while proximal injury would be a function of gender (or factors for which gender is a proxy). This difference invites more detailed studies.

In contrast, both areas of presentation show a similar pattern of psychosocial exposures. As in the full sample model, the psychosocial variance is captured by a combination of Work Very Hard (positively

associated with case status) and Assessed Organizational Support (in a protective relationship with case status). However, while the measure of Demands has a very significant OR (.009) in the Distal WRMSD stratum, it is only near-significant (.063) in the Proximal group.

The biomechanical patterns are quite distinctive make intuitive sense. Distal injury is primarily a function of Whole Hand Grip, Repetitive Hand Motion and Static Postures. By contrast, proximal injury is a function of Repeated Neck Bending, Repeated Push/Pull/Lift and Static Postures.

Table 5:
 Logistic Regression Stratified by WRMSD Diagnosis Categories
 Outcome Variable: Case Status. Cases compared to 553 controls

Independent Variables	Muscle/Tendon N = 597 (44 cases)				Neurological N = 595 (42 cases)				Joint/Arthritis N = 618 (65 cases)			
	C.I.	O.R.		p	C.I.	O.R.		p	C.I.	O.R.		p
		Low	Hi			Low	Hi			Low	Hi	
<u>Control Variables</u>												
Gender	1.45	0.67	3.13	.350	1.16	0.55	2.44	.703	1.33	1.69	2.56	.396
Education Level	0.81	0.59	1.12	.207	0.72	0.48	1.07	.101	0.83	0.63	1.09	.181
Age	1.00	1.00	1.00	.836	1.00	1.00	1.00	.892	1.00	1.00	1.00	.826
Years at Work	0.97	0.93	1.02	.274	1.03	0.93	1.07	.084	1.05	1.01	1.08	.008
<u>Psychosocial/Organizational</u>												
Decision Latitude												
Co-Worker Support												
Supervisor Support									0.72	0.51	1.02	.062
Assessed Org. Support					0.53	0.33	0.83	.006				
Work Very Hard					1.95	0.99	3.83	.053	1.98	1.13	3.49	.017
Machine Paced Work												
Work Mentally Stressful					8.02	1.02	63.3	.048				
<u>Biomechanical: Hours/Day</u>												
Unsupported Hand Work												
Pinch Grip									2.28	1.00	5.19	.051
Hard Whole Hand Grip												
Repeated Neck Bending					12.8	1.65	98.9	.045				
Working in Cold Temp.												
Repetitive Push, Pull, Lift	2.23	1.03	4.85	.042	3.24	1.25	8.36	.015				
Reaching above Chest												
Repetitive Wrist Bend									2.62	1.10	6.22	.029
Vibrating Tools/Machinery												
Repetitive Hand Motion	5.43	0.72	41.1	.101					6.98	0.92	52.7	.060
Computer Keyboard												
Static Postures	5.45	2.24	13.2	.000	2.10	0.88	4.98	.093				
	Initial -2 LL: 222.2 Final -2 LL: 195.3 Model Improvement: 26.9 3 df; p = .000				Initial -2 LL: 227.7 Final -2 LL: 154.9 Model Improvement: 76.8 7 df; p = .000				Initial -2 LL: 285.9 Final -2 LL: 238.9 Model Improvement: 45.0 6 df; p = .000			

Table 5 compares models stratified by different groups of tissue pathology. In these models, the four control variables do not demonstrate significant entries, with two exceptions: education level barely achieves “near-significant” protective status in neurological disorders (its only appearance in these models), and Years in This Type of Work is strongly predictive of joint/arthritis disorders only.

Psychosocial stressors make no significant contribution to the Muscle/Tendon injury model. Work Very Hard and Assessed Organizational Support are explanatory in the Neurological disorder model, together with Mentally Stressful Work. By contrast, Joint/Arthritic disorders are associated with increased levels of Demands; Supervisor Support makes its only appearance in these models as a protective factor. Thus each type of tissue disorder exhibits a distinctive pattern of psychosocial associations.

The distribution of significant biomechanical stressors also generates 3 distinctive groupings. Muscle/Tendon disorders are associated with increased levels of Repetitive Push/Pull/Lift, Repetitive Hand Motions and Static Postures. These exposures involve different types of muscular exertion. The model for Neurological Disorders substitutes Repeated Neck Bending for Repetitive Hand Motion in this set. These exposures may all relate to nerve entrapments in the brachial plexus or cervical region, or some may be indicative of more distal nerve compression syndromes. In a separate pattern, Joint/Arthritis disorders are associated with Pinch Grip (its only entry), Repetitive Wrist Bending and Repetitive Hand Motion—three primarily distal exposures.

Overall, the Muscle/Tendon disorder stratum is poorly explained by this set of predictor variables. No control or psychosocial measures are explanatory; three biomechanical stressors are the only significant entries. By contrast, models explaining the other two classes of injury include more control and psychosocial variables, but in separate and distinct patterns.

Table 6:
Comparison of 3 Type of Work Categories
Comparison of Cases to Controls Within Category; N = Total (cases/controls)

Independent Variables	Professional/Mgr. N = 428 (109/268)				Service/Clerical N = 272 (107/165)				Manual Labor N = 141 (68/73)			
	C.I.	O.R.		p	C.I.	O.R.		p	C.I.	O.R.		p
Control Variables		Low	Hi			Low	Hi			Low	Hi	
Gender	2.12	1.16	3.89	.015	1.46	0.73	2.91	.283	1.93	1.71	5.23	.197
Education Level	0.93	0.74	1.18	.574	1.35	1.98	1.88	.068	0.96	0.62	1.49	.854
Age	1.02	1.00	1.05	.228	1.01	0.98	1.04	.467	0.98	0.94	1.03	.451
Years at Work	1.00	0.97	1.04	.865	1.03	0.99	1.07	.113	1.03	0.99	1.08	.192
<u>Psychosocial/Organizational</u>												
Decision Latitude	0.40	0.23	0.72	.002								
Co-Worker Support												
Supervisor Support									0.57	0.36	0.91	.020
Assessed Org. Support					0.58	0.40	0.83	.003				
Work Very Hard	1.50	0.97	2.32	.072					2.49	0.93	6.69	.071
Machine Paced Work												
Work Mentally Stressful												
<u>Biomechanical: Hours/Day</u>												
Unsupported Hand Work												
Pinch Grip												
Hard Whole Hand Grip												
Repeated Neck Bending	2.94	1.59	5.44	.001								
Working in Cold Temp.												
Repetitive Push, Pull, Lift					1.91	1.00	3.62	.048	12.8	2.66	61.0	.001
Reaching above Chest												
Repetitive Wrist Bend												
Vibrating Tools/Machinery												
Repetitive Hand Motion												
Computer Keyboard												
Static Postures	2.08	1.15	3.77	.016	2.51	1.32	4.76	.005				
	Initial -2 LL: 333.8 Final -2 LL: 280.0 Model Improvement: 53.8 5 df; p = .000				Initial -2 LL: 268.3 Final -2 LL: 236.0 Model Improvement: 32.3 4 df; p = .000				Initial -2 LL: 148.1 Final -2 LL: 114.5 Model Improvement: 33.6 4 df; p = .000			

Table 6 presents the models built in 3 broad Type of Work categories. In these analyses, cases in each group were compared to controls from the same group, only. This results in smaller numbers for analysis and an accompanying loss in power. But the resulting models more accurately reflect which exposures are of interest in each group.

The smaller cells in this analysis make some interpretations difficult. The demographic influences on these occupational groups are noteworthy. Gender is strongly predictive (OR: 2.12) in the Professional/Managerial group only. In the other two groups, years of exposure is the critical control quantity.

The psychosocial variable set shows a similar non-overlap of patterns. Professional/Managerial and Manual Labor cases are marginally predicted by Work Very Hard, but each stratum has a different

protective measure. Decision Latitude is strongly protective against WRMSD for the Professional/Managerial stratum only, while in the Service/Clerical group, Assessed Organizational Support is protective—the pattern seen in most of the other models. For Manual Laborers, Supervisor Support is protective (the only model in which it displaces Organizational Support).

The biomechanical stressors show somewhat distinctive patterns. Professional/Supervisory cases are associated with increased reports of Repeated Neck Bending and Static Postures. Service/Clerical cases are associated with a combination of Repetitive/Push/Pull/Lift and Static Postures. Manual Labor case status is strongly associated with Repetitive/Push/Pull/Lift alone.

DISCUSSION

The preceding tables demonstrate the strengths and weaknesses of a population-based survey. On the one hand, the data allow estimates of associations that should be generalizable to other broadly sampled work populations. Most important, these estimates include the contribution of cases that would otherwise go unreported, thus decreasing the chances for bias encountered in the collection of information from records or within individual work places. Finally, the wide variance in measures allows the separation of psychosocial, organizational and biomechanical associations with outcomes—a separation that is difficult to achieve in studies focused on particular work places or sectors. On the other hand, this wide variance dilutes the associations of many exposures with outcomes, resulting in a somewhat generalized set of conclusions. This dilution, combined with the small numbers in some of the sub-analysis cells, results in the wide confidence intervals seen in some of the tables.

Hypotheses 1, 2, 3 and 4 of the research, that WRMSD outcomes are associated with a complex set of biomechanical, psychosocial and organizational factors, as well as length of occupational exposure, are supported by the analyses. But there were surprises in the analysis. In the biomechanical realm, Repeated Neck Bending, Repeated Push/Pull/Lift, Repetitive Hand Motion and Static Postures are consistently predictive in many of the model, while several other exposures that are generally associated with WRMSD development do not achieve significance in most models. We expect the validation activities now under way to address the question of whether the questionnaire can reliably measure the constructs we intended to measure. The lack of significant entry found for some variables might be a reflection of the different levels of detail implicitly assessed in the biomechanical questions. Static Postures refers to any upper extremity location, while many of the “Repeatedly” questions are more localized and thus do not capture as much variance in the general case definition. Questionnaire revision processes should pay more attention to moving all questions towards a similar level of focus.

Because of resource limitations, we had to select a set of psychosocial and work organization measures much reduced from the ideal. Perhaps because of this limited exposure characterization, the results of the analysis were different from what we expected. Although lack of Social Support has been shown to be a significant predictor of heart disease and morbidity (Johnson & Hall, 1988, Karasek & Theorell, 1990) and of WRMSD symptoms (see introduction), co-worker support never entered the models, and supervisor support only achieved significance in one (predicting reduced case status in Manual Laborers). Assessed Organizational Support maintains the most consistent associations in these models. Bill Jones et al. (1995) proposes that Supervisor Support is the primary conduit through which an employee perceives organizational support—the supervisor is the face of the organization. This might explain how Assessed Organizational Support could capture variance from Supervisor Support (the two constructs have a correlation coefficient of .44), but it does not explain the consistent non-significance of co-worker support. Clearly, more detailed research is required.

Similarly, the limited number of entries of Decision Latitude means that the Demand-Control model (Karasek, 1979) may not be highly explanatory in these models. The OR of an interaction term composed of these two measures was not significant, even in the initial univariate model. However, full assessment of this hypothesis awaits validation of the reduced Demands and Decision Latitude measures used in this research. In particular, the ambiguous interpretation of “Work Very Hard,” out of context, may make it a poor measure of Psychological Demands.

The research indicates the important role psychosocial and organizational factors may play in WRMSD, but the specific psychosocial/organizational hypotheses-- 5, 6 and 7--were not supported by these analyses. Hypothesis 5, that proximal disorders would be more closely associated with psychosocial stressors, is not strongly rejected; the associations of Demands and Assessed Organizational Support are similar in both models. But the significance of Demands in the proximal model is marginal. In testing hypothesis 6, it emerged that the Neurological disorders are most strongly explained by a combination of Assessed Organizational Support (protective) and Mentally Stressful Work, with one of the higher Odds Ratios of the study. These findings suggest that the mechanism hypothesized for the possible effects of psychosocial and organizational stressors on the respondent physiology (muscle tension) is incorrect, and that future physiological research should examine the effects of stress on neural tissue. Alternately, increased muscle tension in the neck and shoulder area may lead more readily to nerve compression or entrapment in the brachial plexus than to muscle-tendon damage. Finally, contrary to hypothesis 7, these

models showed Manual Labor to be the work category in which psychosocial factors had the strongest associations, followed closely by Service/Clerical. The fact that the Professional/Managerial group is the only one in which Decision Latitude has a protective association suggests that more subtle and exposure-specific hypotheses would be appropriate.

We entered gender in all models to control for its possible role as a confounder or effect modifier. In several models presented above, female gender is associated with higher rates of WRMSD reports. These findings are consistent with many studies of office workers (see the review of Punnett & Bergqvist, 1997) and industrial populations (e.g., Hagberg & Wegman, 1987). It is possible that this increased prevalence is a function of physiological and/or anatomical gender differences, but several other possibilities might explain these findings:

1. As with many of the studies, we may not have fully characterized work place exposure. Female gender is often associated with differential distribution of biomechanical and psychosocial stressors within the same job title or type (Punnett & Bergqvist, 1997, Karasek & Theorell, 1990; Messing, Chatigny, Courville, 1998, Messing, Tissot, Saurel-Cubizolles, Kaminski, Bourguine, 1998).
2. Female anthropometry is, on average, smaller than that of males. Yet many types of machinery, equipment, work stations and tools are still designed for the average Caucasian male (Kourinka and Fourcier, 1995), requiring sub-optimal postures, grips, etc. from women.
3. We did not address home exposures in these analyses. Childcare and household demands may expose women to higher levels of physical and psychosocial stressors (e.g., Bergqvist, Wolgast, Nilsson, Voss, 1995). The fact that Years at Work does not enter significantly into the female model, despite its larger size, strengthens the suggestion that unmeasured factors are important in explaining the higher prevalence of cases in the female population.
4. Females and males may exhibit differences in reporting behaviors. Warren's (1997) analysis of the Dutch Monitor data found that females reported higher levels of pain but, importantly, lower levels of long-term sick leave and disability.

The gender models present another puzzle: for both genders, Work Very Hard is a significant risk factor, but while increased Decision Latitude is protective for women, a combination of Organizational and Supervisor Support are protective for men. These are surprising relationships. Johnson, Hall, Stewart, & Theorell (1993) found Decision Latitude to be more important for men in CHD research, and Warren (1997) found support variables generally more protective for women than for men in WRMSD research. It is possible that the population-based, random sampling strategy uncovers different relationships or reporting behaviors. More research is required.

The case of Computer Keyboard Work illustrates several epidemiological problems simultaneously. Clinical experience shows that VDT work has a strong association with a number of WRMSD entities. Yet in our univariate and full multivariate models, the variable achieves a near-significant ($p = .085$ and $.065$, respectively) "protective" entry. There are at least three explanations. When exploring the dichotomous exposure variable, it became clear that computer work did not significantly distinguish between cases and controls unless it was performed more than 3 hours per day. It is possible that computer use of less than 3 hours may be associated with jobs that have more variety yet are not in the high-risk manual labor category. In addition, the average case prevalence in respondents reporting 1-3 hours exposure (31.2%) is actually slightly lower than that of the group reporting 0 hours (36.3%). These respondents with no VDT exposure may, on average, hold jobs with higher levels of other risks, resulting in a specious "protective" entry in the models. Thirdly, the two strongest exposures in the full case-control regression, Repeated Neck Bend and Static Postures, are probably confounders of the Computer Keyboard Work effect.

Future work, with larger databases, should concentrate on a more particularized set of case definitions that would allow analysis within more precise symptom categories. In addition, this research should develop a method for quantifying different degrees of "caseness", perhaps using the pain intensity scale in the present research. Preliminary analyses on a parallel set of Workers' Compensation case interviews suggest somewhat different types and strengths of association from those found in the present sample. Our future research will explore the effect of "degree of caseness" on the models. Intervention strategy could well benefit from this knowledge; different points of intervention might be recommended for departments and companies characterized by different levels of WRMSD. There is precedent for this hypothesis. In the Organizational Development arena, Golembiewski, Munzenrider, & Stevenson (1986) have demonstrated

the need for quite different intervention approaches to reduce “burnout”, dependent on the degree of “burnout” in the organization or department.

Methodological Implications

1. The questionnaire items from the OSHA draft standard have received partial validation from this research. In dichotomous form, they are significantly associated with WRMSD status, demonstrating their ability to discriminate between cases and non-cases. Planned medical case-confirmation and independent exposure confirmation will further this validation process
2. The use of dichotomous biomechanical measures, while reducing the precision of effect estimation, avoids some pitfalls involved in using measures with many categories (e.g., hours of exposure). The method employed here allows identification of first-cut associations. We can now use the data from this study to calculate the dichotomization point for each variable that best distinguishes cases from non-cases. Preliminary analysis shows that, while the selected dichotomization point of this study (0 hours/>0hours) is the best point for about half of the variables, a 2 hour/>2 hour cut is more effective in another 5 variables. Work at a Computer Keyboard best distinguishes cases from controls when cut at 3/>3 hours. In a population study, with its wide variation in exposure and outcome associations, this increased ability to predict outcome measures is valuable in pointing the way toward later, more precise analyses of exposure-outcome association.

Strengths of the Study

The population-based sampling strategy employed in this study allows less biased estimates of exposures, outcomes and rates in the general working population than could be obtained with company-based studies or studies based on Workers’ Compensation cases. Most importantly, the study methodology contacts individuals who do not appear in the State-based surveillance or Workers’ Compensation databases, allowing exposure/outcome estimation for previously unidentified possible cases. In addition, although the wide range of work places and jobs dilutes most of the effects being studied, it also provides a high degree of variance in all measures. This is statistically valuable for estimating effect. It is particularly valuable in separating the effects of biomechanical, psychosocial and organizational exposures. In many company- or sector-based studies, biomechanical and psychosocial exposures are so collinear that it is difficult or impossible to separate their associations.

Limitations of the Study

An initial weakness is the limited number of psychosocial questions we were able to include in the interviews, due to resource constraints. In particular, the construct of Psychological Demands was not well characterized in this study (the single item, “Work very Hard” is ambiguous in referring to both physical and psychological demands). Although the validated measures we selected give a general overview of the psychosocial work environment and its associations with WRMSD reports, proposed future work with this study population will have to characterize psychosocial exposures in greater detail.

Second, the major weakness of the study is its cross sectional design. It is not possible to determine the direction of causation in the associations found here. In particular, the associations between symptom outcomes and psychosocial and organizational stressor levels present interpretation ambiguities. Yellen & Callahan (1995), reviewing the arthritis literature, document the impact of musculoskeletal conditions on depression, coping strategies, anxiety, cognitive changes, self-efficacy and learned helplessness. They also note that some of these psychological changes may, in turn, predict clinical outcomes. Even our planned longitudinal studies may have difficulties untangling these hypothesized feedback loops.

The cross-sectional nature of the study also increases the chances for several types of information bias. Simple recall bias may artificially elevate or underestimate reports of exposures, symptoms, or both. In particular, because the study is based entirely on self report, it present the danger of common-instrument bias—reporting bias generated by the collection of exposure and outcome data in the same instrument. There exists an extensive literature analyzing the problems and validity of self-report data (e.g., Frese & Zapf, 1988, Katz, Punnett, Simmons, Fossel, Mooney, & Keller, 1996, Kristensen, 1995). In general, this literature supports the validity of self-report data if it is collected in a form incorporating a small number of categories and, ideally, if it is compared to records, physiological measurement or observation. Our group is currently performing symptom- and exposure-validation activities that will address this last suggestion. Michela, Lukaszewski, & Allegrante (1995) also suggest that patterns of association are harder to reproduce by biased reporting than single associations. The complex patterns of association uncovered in

our analyses, with wide differences between models, suggest that reporting bias may be within acceptable levels.

Third, this analysis was done at a high level of generalization. The use of case/non-case as the initial outcome variable was useful for this first approach, since more precise categories of disease type resulted in much smaller cells and reduced ability to detect differences. Categorizing symptoms into distal/proximal groups and musculo-tendonous/neurological/joint related groups resulted in a loss of significance, but generated directions for more focused future studies.

The 3 Type of Work categories used in this analysis also are subject to significant misclassification error, due to the large variety of job tasks contained within each broad type of work. We chose to combine in the professional/managerial category jobs that generally include some computer work but also involve a large variety of other operations involving neither heavy physical labor nor prolonged computer operation. The service/clerical category includes jobs with a higher level of repetitive upper extremity motions, including computer work. The manual labor category involves more heavy physical exertion, often in combination with repetitive upper extremity motions. There is substantial overlap between occupational groups, and variance within each group is necessarily large.

Fourth, telephone surveys have known biases, which the random-digit dialing approach with repeated attempts at contact (6) and regional stratification can only partly control. Response rates are typically lower than those reported for in-person studies (our overall study response rate was just under 70%), presenting the possibility of non-responder bias. "Wave" analysis, comparing respondents contacted after different numbers of attempts (1-6), did not uncover significant differences in those that were harder to contact. But we have no way of comparing these responses to individuals who could not be contacted. In addition, telephone surveys tend to under-represent individuals from lower socioeconomic strata and from minority groups. This study contacted minority respondents at a rate half that of the true population distributions.

Finally, the instruments used to construct the questionnaire were not designed for telephone administration and were sometimes altered for this use. The Nordic Questionnaire makes use of a body diagram. The OSHA draft checklist was designed for use by an observer, not for self-report use. Informal pilot participation in the questionnaire administration process suggests that the questions are understandable. The condensation of JCQ questions predicts changes in blood pressure (Landsbergis et al., 1996) but has not yet been validated for use with WRMSD symptoms. Formal validation studies of exposure and symptom status are presently underway to determine the validity of the new instrument.

Because this is a broad-based, self-reported, cross-sectional population sample of exposure and outcome, these categorizations must be seen as an epidemiological broad brush. The present work is designed to address a lack in the epidemiological literature--the scarcity of population-based measurements of work-related musculoskeletal symptoms and exposures. Work is proceeding on instrument validation and plans for a prospective cohort study designed to address many of the problems outlined above. This work thus generates hypotheses that can be subjected to more detailed longitudinal epidemiological and physiological study.

CONCLUSIONS

Hypotheses 1-4 were supported by the research; hypotheses 5-7 were not. WRMSD demonstrates strong associations with a complex web of biomechanical, psychosocial and organizational factors. Exposure to each of these 3 classes of risk factors has independent associations with WRMSD outcomes. Likewise, exposure duration, as measured by number of years in the job where injury occurred, is consistently associated with disease outcome in most models. While psychosocial exposures are significantly associated with WRMSD outcomes, there are intriguing differences in pattern of association, depending on symptom location, symptom tissue pathology, and Type of Work category.

The research may have implications for intervention strategies. First, given the strength of the independent associations of disease with biomechanical, psychosocial and organizational stressors, it is unlikely that interventions targeted to only one of these risk factor classes will be able to fully resolve many WRMSD problems. An integrated and multi-factoral approach is indicated, addressing biomechanical and psychosocial risk factors, along the lines of that proposed by Frazier, Stenberg and Fine (1996). Second, the significant entry of organizational perceptions into the models suggests that a multi-level approach may also improve effectiveness of WRMSD control efforts. Organizational culture and policy may have implications for WRMSD development and control.

The population-based analysis of otherwise unreported cases and exposure/outcome relationships is crucial to understanding the etiology of WRMSD. This research has generated a wide range of new hypotheses, to be the basis for future, longitudinal studies. At the same time, three types of detailed study should parallel this work: a) physiological studies, aimed at identifying the mechanisms by which psychosocial, organizational and biomechanical stressors exert their effects within the body, b) studies within sectors, industries, and individual workplaces, identifying in more detail disease and exposure relationships, and c) organizational studies aimed at uncovering the ways in which organizational factors can exacerbate or protect against disease. The goal is always to develop knowledge needed to improve the efficacy of intervention efforts.

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Appendix I

Measures Used in the Analysis & Block of Entry into the Logistic Models

Block 1 **Control Variables**

1. Gender (M = 1, F = 2)
2. Education Level (5 levels)
3. Age (by year)
4. Years in this Type of Work (by year)

Block 2 **Psychosocial Scales (see following page)**

1. Decision Latitude (continuous)
2. Co-Worker Support (continuous)
3. Supervisor Support (continuous)
4. Assessed Organizational Support (continuous)

Block 3 **Demand Items**

1. Work Very Hard (4 category Likert Scale)
2. Mentally Stressful Work (no = 0; yes = 1).
3. Working on an assembly line or at a speed controlled by the machine pace (no = 0; yes = 1).

Block 4**Fine Motor & Computer Items**

1. Repeatedly moving hands every 15 seconds or less (no = 0; yes = 1).
2. Working at a computer keyboard (no = 0; yes = 1).
3. Holding the neck, shoulder, arms or hands in one position for a long time (no = 0; yes = 1).
4. Performing Hand work or keyboard work without an arm or wrist support (no = 0; yes = 1).
5. Holding an object by pinching with fingers (no = 0; yes = 1).

Block 5**Whole Body Exposures**

1. Repeatedly and strenuously pushing, pulling or lifting (no = 0; yes = 1).
2. Repeated reaching above chest height (no = 0; yes = 1).
3. Repeatedly bending wrists strongly up, down or to either side (no = 0; yes = 1).
4. Working with hand-held vibrating tools or machinery (no = 0; yes = 1).
5. Grasping an object hard with your whole hand. (no = 0; yes = 1).
6. Repeatedly bending the neck in any direction (no = 0; yes = 1).
7. Working in cold temperatures (no = 0; yes = 1).

Appendix II
Composition and Reliability of Psychosocial Scales

Scale Name	Component Items	Cronbach-alpha
Demands	My job requires working very hard	(single item)
Decision Latitude	My job requires that I learn new things My job involves a lot of repetitive work (reversed) My job requires me to be creative My job allows me little freedom to decide how to do my work (reversed) I have a say in decisions	.623
Coworker Support	People I work with take a personal interest in me People I work with are helpful in getting the job done	.682
Supervisor Support	My supervisor is concerned about the welfare of those under him/her My supervisor is helpful in getting the job done	.780
Assessed Organizational Support	My job is secure Management cares about me I am sufficiently informed about developments within the company	.761