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Self-Reported Hand and Wrist Arthritis and Occupation: Data From the U.S. National Health Interview Survey–Occupational Health Supplement

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Background *There is a paucity of population-based studies examining occupational hand-wrist arthritis. We examined relationships between hand-wrist arthritis, occupation, and biomechanical exposures in the U.S. National Health Interview Survey–Occupational Health Supplement.*

Methods *A randomized, multi-stage, and cross-sectional national prevalence survey was carried out.*

Results *Self-reported, medically attended hand-wrist arthritis was common among employed persons (period prevalence 1.58%; lifetime prevalence 3.58%). Highest prevalences occurred among technicians, machine operators, assemblers, and farmers, and in the mining, agriculture, and construction industries. Work requiring repetitive hand bending and twisting was associated with hand-wrist arthritis (Odds Ratio 1.43; 95%CI: 1.11–1.84; P = 0.005). Among workers with hand arthritis, 7.4% had made major changes in their work, 7.6% missed work, and 4.5% stopped working or changed jobs because of the problem.*

Conclusions *Our study links hand-wrist arthritis to occupation and potentially modifiable workplace ergonomic factors. The spectrum of hand-wrist "cumulative trauma" disorders may considerably exceed that of soft-tissue injuries like carpal tunnel syndrome and tendonitis, and may include arthritis, a widely prevalent, disabling condition.* Am. J. Ind. Med. 42:318–327, 2002. *© 2002 Wiley-Liss, Inc.*

KEY WORDS: arthritis; hand; industry; occupations; prevalence; wrist

INTRODUCTION

Discussion of "cumulative trauma" disorders of the hand and wrist typically focuses on soft tissue disorders, such as tendonitis, carpal tunnel syndrome, and myofascial injuries. There is, however, a theoretical basis for the concept of chronic work-related, joint injury leading to hand and wrist arthritis, especially degenerative osteoarthritis [Peyron, 1986; Genti, 1989; Felson, 1994; Allan, 1998]. Case reports [Williams et al., 1987; Turner, 1989; Poole, 1993; Schmid et al., 1999], workplace prevalence surveys [Hadler et al., 1978], and limited case-control studies [Nakamura et al., 1993; Elsner et al., 1995] also support this concept. Further, while the biomechanical exposure mechanisms are only

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partly shared, there is a growing body of evidence linking occupation and osteoarthritis of the lower extremity weight-bearing joints such as the hip and knee [Felson, 1990; Vingard et al., 1991; Croft et al., 1992; Vingard, 1996; Yoshimura et al., 2000].

Evaluation of occupational risks for arthritis is a clearly stated priority in consensus statements on arthritis research needs [Brandt et al., 1986]. It is also a stated priority for surveillance, epidemiology, and prevention research in the U.S. National Arthritis Action Plan [Arthritis Foundation et al., 1999]. As yet, however, there is a paucity of population-based studies currently available examining the possibility of occupational hand-wrist arthritis. Hand-wrist arthritis causes substantial disability, yet is less well studied epidemiologically than arthritis of the weight bearing joints, such as the hip and knee. For significant numbers of cases, a precise etiology is unknown. Treatment options are limited; hence, identifying new strategies for disease prevention is important. The evaluation of possible associations between repetitive use at work and hand-wrist arthritis is therefore pertinent.

A population based resource which contains data on hand and wrist arthritis in relation to work and occupational risks is the U.S. National Health Interview Survey, Occupational Health Supplement (NHIS-OHS) [Massey et al., 1989; Park et al., 1993]. The NHIS-OHS is a cross sectional household interview survey of illness and injury among employed persons, and has produced a number of important analyses of the prevalence and causation of work related disorders, such as carpal tunnel syndrome, back pain, dermatitis, and asthma [Tanaka et al., 1995; Lalich and Sestito, 1997]. The NHIS-OHS protocol collected prevalence data for self-reports of hand-wrist arthritis, for certain biomechanical risks, and for a worker's industry and occupation. Analysis of NHIS-OHS data may therefore potentially provide useful insight into the prevalence and etiology of hand-wrist arthritis in the U.S. working population.

MATERIALS AND METHODS

Sampling Frame

The National Health Interview Survey is an annual in-person household interview survey conducted as a multistage probability sample of the non-institutionalized U.S. civilian population [Massey et al., 1989]. In 1988, an Occupational Health Supplement, jointly sponsored by the National Institute for Occupational Safety and Health (NIOSH) and the Bureau of Labor Statistics (BLS), was designed to provide U.S. national prevalence estimates for selected occupational conditions and their risk factors. Detailed descriptions of the data set, methods of statistical analyses, and summary data descriptions were previously published [Massey et al., 1989; Park et al., 1993; Tanaka et al., 1995]. Out of the 50,061 initially sampled households in the 1988 NHIS, the NHIS-OHS was completed by 44,233 adults (response rate 88%). Of these, there were 30,074 ''recent workers,'' defined as adults, 18 years of age or older, who worked at any time at a civilian job or business (excluding household work) during the 12-month prior to interview.

NHIS-OHS Questionnaire Protocol

Standard NHIS criteria were employed to identify hand-wrist arthritis cases. Case inclusion criteria for ''medically-called'' hand-wrist arthritis were:

- ''Prolonged'' hand-wrist discomfort (''pain, burning, stiffness, numbness, or tingling in the hand, wrist, or fingers felt 20 or more days, altogether, or 7 or more days consecutively within the last 12 months'').
- Evaluation by a medical provider for the hand-wrist discomfort and a report of medical provider diagnosis of hand-wrist arthritis. This survey question was not posed as a leading question. Interviewees were asked: ''What did the (attending) medical person call your hand or wrist discomfort?'' If the response was ''arthritis,'' a case was classified as ''medically-called hand-wrist arthritis.'' The use of a dual case-definition criteria including not only a self report of medically attended hand arthritis, but also ''prolonged'' symptoms derived from NIOSH field study experience [Baron et al., 1996; Silverstein et al., 1997]. In these studies, survey respondents reporting ''prolonged'' symptoms by these criteria had a high probability of physical examination findings and clinical diagnosis of a musculoskeletal disorder.
- Exclusion criteria were any hand-wrist arthritis due to prior trauma or fractures.

For self reported data on cumulative lifetime hand-wrist arthritis prevalence, respondents were asked: ''Please tell me if you have ever had the following condition: arthritis of the hand, wrist or fingers?'' To exclude cases of post-traumatic arthritis from the data, hand-wrist arthritis cases were excluded if there was a history of prior hand-wrist fracture. No diagnostic criteria were specified for either medically called or cumulative lifetime arthritis reports, nor was there any additional probing, inquiry, or validation at the time of the interview.

The 1988 NHIS-OHS contained two questions on hand-wrist biomechanical exposures, both linked to a respondent's most recent job within the last 12 months.

- ''Did your job require you to bend or twist your hands and wrist many times an hour?''
- ''Did you work with hand-held or hand-operated vibrating tools or machinery?''

The average hours per workday of each activity was then obtained for each affirmative answer.

A respondent's occupational job title and industry of employment was recorded using NHIS survey standards. The principal focus of the NHIS-OHS survey was the most recent job within the prior year, but information for occupation of longest employment was also collected and is the focus of this study. The survey protocol did not capture a complete lifetime work history. Additional surveyed variables were incorporated into our analysis: age, gender, family income, educational attainment, cigarette smoking, body mass index (≥ 25), prior hand or wrist fracture, health status and general activity limitations, and vocational impairments (missed a day of work, major change in work activities, stopped or changed jobs because of hand-wrist arthritis).

Data Analysis

Variables and data sets for study data were created using SAS Version 6 and analyzed with Software for Survey Data Analysis (SUDAAN), designed for analysis of data from complex multistage surveys [Shaw et al., 1997]. As recommended by NHIS, all statistical analyses were weighted to represent the U.S. population [Massey et al., 1989]. The results reported here therefore represent U.S. national estimates. One-year period prevalence and standard error (SE) were used for comparability with previous studies, with replacement sampling assumed in all estimates. Statistical calculations for adjusted odds ratios and their confidence intervals were based on multiple logistic regression analyses. To ensure stable estimates, we studied aggregated ''major'' occupational and industry groupings (NHIS Occupation and Industry Recode 2). For occupation and industry sector analyses, a respondent's job with longest reported employment was used, incorporating a minimum of 5 years employment in an occupation or industry to provide a plausible period of exposure to biomechanical factors prior to development of arthritis. Biomechanical risk factor data was only available for a respondent's current job. The effects of biomechanical factors on arthritis prevalence were analyzed by multiple logistic regression both as dichotomous contrasts (ever, never exposed), and as continuous variables using person hours of exposure, the product of typical daily hours of use per year and years worked (assuming 240 days per working year).

RESULTS

U.S. National Prevalence Estimates: Demographic Trends, Risks, and Impairments

Among the 30,074 recent workers interviewed, there were 489 cases of medically called hand-wrist arthritis, representing an estimated 1,986,018 cases and a 1.58% (SE = 0.09) 1-year period prevalence in the U.S. working population. The cumulative lifetime prevalence for hand-wrist arthritis was 3.58% (SE = 0.14) representing 4,502,245 cases nationally, based on 1,105 self-reports. Further statistical analyses showed essentially no difference in results for either medically-called or self-reported cumulative lifetime prevalence data; hence we present only results for medically-called arthritis in this article.

There was increasing hand-wrist arthritis prevalence in both sexes by age (≥ 40 vs. < 40 years), but with additional stratification, some leveling was noted at the oldest age categories. Increasing age was the single most important risk factor for hand-wrist arthritis (multivariate adjusted odds ratio 5.47; 95%CI: 4.19–7.15; $P \leq 0.001$). Female gender was also an important observed risk (multivariate adjusted odds ratio 2.36; 95%CI: 1.85–3.01). The overall female to male prevalence ratio approximates 1.88:1; however, for younger workers in the 25–34 year age group, gender ratio is closer to one. Hand-wrist arthritis is significantly more prevalent in whites (1.7%, SE = 0.09) than non-whites (1.1%, SE = 0.18), the multivariate adjusted odds ratio for white ethnicity being 1.75 (95%CI: 1.19–2.57). A female preponderance is seen equally in both ethnic groups. U.S. regional analyses showed higher prevalence in the Midwest (1.80%) and the South (1.68%) than the West (1.42%) and Northeast (1.32%). Also lower gender ratios are seen in the Midwest (1.69) and the South (1.72), reflecting higher prevalence of hand-wrist arthritis reports among men in these regions.

Medically-called hand-wrist arthritis showed a decreasing trend in prevalence with increasing educational attainment in unadjusted data, where those with no more than a secondary school education had highest risks, but this did not achieve statistical significance in multivariate adjusted comparisons. Income was not found to be significantly associated with hand-wrist arthritis risk. Increased hand-wrist arthritis prevalence was noted in workers who had ever smoked cigarettes (multivariate adjusted odds ratio 1.40; 95%CI: 1.14–1.73). Body mass index (≥ 25 vs. < 25) also had a significant association with hand-wrist arthritis risk (multivariate odds ratio 1.52; 95%CI: 1.20–1.92).

Among the self-reported, medically-called hand-wrist arthritis cases, 7.0% (SE = 1.3) reported significant limitation or inability to perform a major life activity. Vocationally, 7.4% (SE = 1.3) of workers with medically called hand-wrist arthritis had made a major change in work activities, 7.6% (SE = 1.3) missed a full day of work because of the condition, and 4.5% (SE = 0.9) had recently stopped working or changed jobs because of the problem. This latter corresponds to 89,444 cases of major employment limitation per year nationally.

Occupation and Industry Associations

Assessment of medically called hand-wrist arthritis risk by a respondent's longest reported occupation and industry of

TABLE I. U.S. Occupations With Highest Prevalence of Medically Called Hand-Wrist Arthritis, 1988 NHIS-OHS National Survey

	Estimated n	OR	95%CI	*P*
Occupational category				
Military	21,749	8.28	1.95–35.2	0.004
Technicians	98,062	3.81	2.01–7.21	0.001
Machine operators, assemblers	187,049	3.20	1.82–5.63	0.001
Farmers, forestry, fishing	61,068	2.71	1.27–5.76	0.01
Professional specialties	338,637	2.63	1.66–4.18	0.001
Laborers, handlers, helpers	52,966	2.40	1.01–5.68	0.05
Transportation and material movers	60,528	2.33	1.05–5.16	0.04
Service occupations	206,778	2.32	1.34–4.01	0.003
Precision production, crafts, repair	174,733	2.09	1.21–3.63	0.01
Administrators, managers	172,246	2.02	1.17–3.50	0.01
Clerical, administrative support	324,909	1.89	1.16–3.08	0.01
Industry sectors				
Mining	29,231	5.35	1.75–16.3	0.004
Armed forces	45,101	4.76	1.97–11.5	0.001
Agriculture, forestry, fisheries	82,522	3.60	1.87–6.93	0.001
Construction	135,935	3.48	1.93–6.26	0.001
Public administration	122,402	2.60	1.36–4.97	0.004
Professional services	491,504	2.58	1.66–4.01	0.001
Manufacturing	385,573	2.50	1.56–4.00	0.001
Finance, insurance, real estate	114,243	2.27	1.28–4.01	0.005
Retail trade	236,611	2.19	1.29–3.70	0.004
Business and repair services	58,022	2.05	1.00–4.20	0.05

n = Estimated numbers of hand-wrist arthritis cases per category, U.S. working population 1988; OR = multivariate Odds Ratio estimates for respondents' longest reported occupation or industry and with a minimum of 5 years of employment (relative to workers with less than 5 years employment in their longest occupation). OR estimates are adjusted for age, gender, ethnicity, body mass index, and cigarette smoking. CI, confidence interval, *P*, significance level.

employment is presented in Table I. This table lists the highest risk occupations and industry categories for hand-wrist arthritis. The estimates are for workers with a minimum of five or more years of employment in a specific job or industry category, and are adjusted for major potential confounders (age, gender, body mass index, ethnicity, and smoking status). Military occupations and the armed forces sector have highest arthritis risks. The results for this group should be viewed with caution, however, as the NHIS-OHS is a survey of the U.S. civilian population, and these findings may represent military retirees with an increased risk of arthritis disability. Among civilian occupations, technicians, machine operators, farmers, laborers, and crafts and production workers are among the highest risk occupational groups for hand-wrist arthritis. ''White collar'' office work, with manual tasks that include handwriting, paper handling, and computer keyboarding, is also apparently associated with risk of hand-wrist arthritis, though with a lesser magnitude of risk than manual laborers. Professional specialists are also noted to have some increased risk.

High-risk civilian industries for hand-wrist arthritis mirror trends seen in the occupational category analysis. Mining, agriculture, construction, and manufacturing have the highest risks, but traditionally ''white collar'' industry sectors such as retail trade and finance and insurance have lesser but still significantly elevated risks. Professional services and public administration again are identified as having some elevated risk.

Arthritis and Biomechanical Risk Factors

The prevalence of work with repetitive bending/twisting the hands and wrists was 50.5%, and for jobs using hand-held vibrating tools, 18.3%. The dichotomous (ever/never) multivariate adjusted prevalence odds ratio between hand-wrist arthritis and occupational hand-wrist bending is 1.43 (95%CI: 1.11–1.84; $P = 0.005$). For hand held vibrating tools, the multivariate adjusted odds ratio was not significant (OR 1.13; 95%CI: 0.79–1.60). In multivariate modeling,

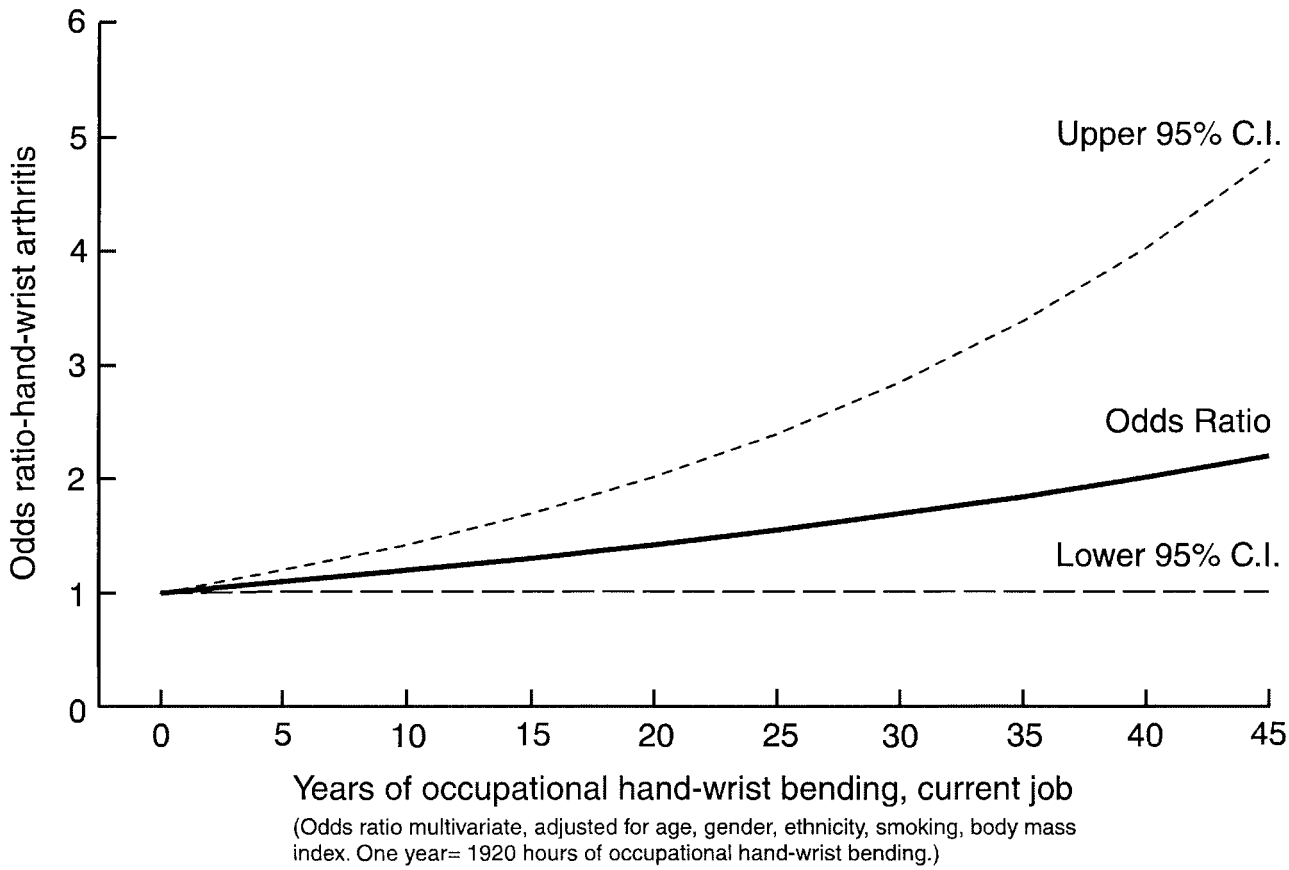

FIGURE 1. Hand-wrist arthritis risk and occupational hand-wrist bending: U.S. NHIS-OHS prevalence survey, 1988.

biomechanical risks considered as continuous variables showed a clear dose response relationship between person-hours of work exposure to hand-wrist bending and medically called hand-wrist arthritis (Fig. 1). For example, the estimated odds ratio for approximately 35 years (70,000 hr) of full time work with repetitive hand and wrist bending jobs is 1.84 (95%CI: 1.00–3.39). No such trends were observed between hand-wrist vibration exposure and arthritis, or general measures of amounts of strenuous physical activity, either for medically-called or cumulative lifetime prevalence self-reports.

DISCUSSION

This report can only be interpreted as a hypothesis generating study of an important national database that demonstrates statistical associations between hand/wrist arthritis generally, and both occupation and biomechanical risks. Definitive studies confirming or refuting the associations need to be done using other methodologies. Primary limitations of the present study are self-reported data and lack of specificity for sub-types of arthritis.

Validity of Self-Reported Arthritis Data

We feel that self-reported arthritis data in the NHIS-OHS survey have sufficient validity for the present analytic purposes because:

- The standard NCHS survey data collection protocol asks the respondent only about medically treated conditions. The respondent is asked to report what the physician called the condition—termed a "medically-called" condition. This is substantially different from asking the survey respondent to self-diagnose.
- To evaluate the utility of self-reported, "medically-called" data for medical conditions including arthritis, NCHS performed four validation studies. These compared data from standard NHIS interviews against preexisting medical records [Balamuth and Shapiro, 1965; Linder et al., 1965; Madow, 1967; National Center for Health Statistics, 1994], and found moderate concordance (Kappas = 0.48). Further, validation studies comparing self-reported arthritis to physical exam diagnosis give somewhat higher rates of agreement (see below).

- The U.S. National Health Interview Surveys, including the 1988 NHIS-OHS are widely used for analytic studies and health planning purposes [Lalich and Sestito, 1997]. On a population level, the NHIS survey classification of interviewees as medically-called arthritis cases has been considered to have reasonable validity, primarily because the NHIS national age-specific prevalence for medically-called arthritis is similar to estimates for clinically confirmed osteoarthritis (OA) and rheumatoid arthritis (RA) in the first National Health and Nutrition Examination Survey (NHANES I) [Cunningham and Kelsey, 1984].
- Self-reported, medically-called NHIS arthritis survey data are used by leading arthritis epidemiologists as the basis for influential analyses of U.S. arthritis prevalence and impact, providing key estimates on the national economic and social burden of arthritis related disability [Verbrugge et al., 1991; Yelin, 1995; Yelin and Callahan, 1995; Lawrence et al., 1998]. These studies are the basis for current public health planning and federal arthritis policy making.
- Additionally, there is evidence that strictly self-reported (i.e., not ''medically-called'') arthritis has fair validity for population survey studies. Parallel survey interview and clinical examination studies such as the Commission on Chronic Illness Survey found extremely high concordance for RA [Krueger, 1957]. Also, data from NHANES I [Leigh and Fries, 1994] showed little difference in statistical modeling using either self reported arthritis or clinically defined arthritis based on knee X-rays. March et al. [1998] confirmed self-reports of definite OA in a high proportion of cases (kappa = 0.81), the general diagnosis of OA being more reliable than reports for site-specific disease.
- In self-reported data from prevalence surveys, general disease categories such as ''arthritis'' are more accurately reported than more specific ones [Colditz et al., 1986; Cox and Iachan, 1987].
- To increase the diagnostic specificity of the arthritis data in the present study, exclusion criteria were used to eliminate all other specific and non-specific causes of hand/wrist pain reported by survey respondents. Separate reports covering these conditions (such as carpal tunnel syndrome, tendinitis, etc.) were previously published [Tanaka et al., 1994, 1995, 1997, 2001]. Also any cases of post-traumatic arthritis were excluded from analysis.
- Finally, the NHIS hand/wrist arthritis case definition was narrowed to include only cases with prolonged hand-wrist pain. Clinical examination field studies of self-reported upper extremity symptoms [Baron et al., 1996; Silverstein et al., 1997], show that respondents with prolonged pain had significant likelihood of physical examination findings and clinical diagnoses.

Therefore, while there is inevitable imprecision in the classification of NHIS-OHS survey respondents as hand-wrist arthritis cases, this isn't likely to have affected overall study results. Epidemiologically, while the ideal for analytic studies is a highly sensitive and specific case definition, less precise case definitions can be usefully employed to develop associations, in a large-scale multi-stage probability based sample survey such as this. In the current study, the imprecision that is present should function to make relationships weaker than what they would be with a more precise definition, so that any relationships found in the present study are likely to be valid.

Diagnostic Specificity and Study Referents

Lack of diagnostic specificity, i.e., the fact that the data set permits the examination of hand/wrist arthritis only as an aggregate, is a serious study limitation. Strictly speaking, it is not possible to say whether the associations found are due to any one specific type of arthritis, for example, RA or OA. Hand-wrist osteoarthritis is probably the most likely study referent, based on the following considerations.

Existing hand/wrist arthritis prevalence studies [Lawrence et al., 1989, 1998; Silman and Hochberg, 1993; Felson, 1998] demonstrate that symptomatic hand/wrist OA is approximately 2.5 times as prevalent as hand-wrist RA. Other known causes of hand/wrist arthritis are orders of magnitude less prevalent, and even in the aggregate could not affect our study results. Although some fraction of hand-wrist arthritis cases presenting to physicians or researchers isn't strictly classifiable, one can estimate from these reviews that osteoarthritis accounts for approximately 70% of prevalent U.S. symptomatic hand-wrist arthritis. The overall data set therefore principally represents OA and RA cases, and from a strictly numerical point of view, hand-wrist OA, known to be more widely prevalent, is the likely referent for the present study.

Both OA and RA are known to have female gender predominance, but for rheumatoid arthritis, female predominance is especially marked. The female/male gender ratio for hand-wrist arthritis cases in the present study was 1.9:1, a ratio much more characteristic of osteoarthritis than rheumatoid arthritis. Also, reviewing the associations found, it is especially notable that many of the highest risk work settings for hand-wrist arthritis are occupations or industries where males predominate—such as agriculture, forestry, fishing, construction laborers, mining, manufacturing, and general laborers. Such associations are unlikely to be attributable to RA.

An analysis of demographic and non-occupational risk factors for hand-wrist arthritis in the data set replicates the known epidemiologic associations for OA, rather than RA [Silman and Hochberg, 1993]. There is a pattern of increasing

prevalence with age and female gender, except below 45 years of age, and a positive association with increasing body mass index. Regionally, increased arthritis prevalence in the southern U.S., especially among males, is clearly reflected [Pincus et al., 1989]. There are also non-significant trends towards lower prevalence with increasing educational attainment [Leigh and Fries, 1994].

Occupation-specific associations in the present study have precedents in the hand OA literature. Increased hand-wrist arthritis risk in manual laborers was seen in a U.S. Bureau of the Census Survey [Wan, 1972] and in NHANES I, which demonstrated increased hand OA prevalence among craftsmen, foremen, and related workers [Engel and Burch, 1966]. Hand OA risk in farmers and the agricultural sector [Schmid et al., 1999] and in office workers [Elsner et al., 1995] have both been previously observed. The associations between hand-wrist arthritis and professional specialties noted in the present study, however, have no prior precedent. They may result from risks specific to certain occupations, or from reporting bias due to better access to medical care.

The literature provides some support for the biologic plausibility of an occupation-hand OA association [Felson, 1994; Cooper, 1995; Jensen et al., 1999]. Manual laborers may be prone to OA, often in upper extremity joints not usually affected by OA [Felson, 1998, 1999], such as the metacarpal-phalangeal joint OA [Fam and Kolin, 1986; Williams et al., 1987; Ulreich and Klein, 1991; Jensen et al., 1999; Schmid et al., 1999]. Studies of textile workers and others [Hadler et al., 1978; Nakamura et al., 1993] indicate that work requiring fine pincer grip conveys risk of distal interphalangeal joint finger OA. Longitudinal data from the Framingham study [Chaisson et al., 1999] found significant associations between grip strength and OA of the proximal interpahalgeal, metacarpo-phalangeal, and thumb basal joint in men and in women's metacarpophalangeal joints. Occupation was statistically controlled as a confounder, implying significance, but occupation-specific data wasn't presented.

With respect to the presence of RA cases in the data, workplace aggravation of a principally non-occupational condition may contribute to the associations demonstrated, a factor one cannot control. While from the main analytic viewpoint this is undesirable, from another perspective, the aggravation of pre-existing conditions is an occupationally salient issue, and is recognized in most jurisdictions as the basis for a valid workers' compensation claim.

Other Strengths and Limitations

NHIS-OHS study design

The major strength of the 1988 NHIS-OHS survey is that it is a large, multistage probability sample of the U.S. working population, with a high participation rate and a minimum of selection bias [Massey et al., 1989]. The cross sectional design, however, is an important theoretical limitation with respect to causal inference, especially to the extent that there is a long latency between workplace biomechanical exposure and onset of hand-wrist arthritis.

The 1988 NHIS-OHS survey design is limited in the reference population to which it can be safely generalized. Persons previously in the U.S. workforce, but not employed during the preceding year were not interviewed. Prevalent cases and associations with workplace factors are therefore underestimated, as more serious cases of hand-wrist arthritis in former workers (i.e., the permanently disabled), and any cases in retirees are excluded [Lalich and Sestito, 1997]. This is an especially important limitation in case ascertainment, since only one half of severe hand arthritis cases are estimated to be still actively employed [Pincus et al., 1989]. The proper reference population for the present survey would therefore be a mild to moderately ill spectrum of currently working hand-wrist arthritis cases.

The 1988 NHIS-OHS survey truncates a respondent's work history [Lalich and Sestito, 1997]. Biomechanical risks are linked solely to the respondent's most recent job, favoring detection of conditions with short latencies between exposure and disease onset. To the degree that current employment is unrepresentative of lifetime work history, estimated magnitude of associations diminishes. Occupational title analyses use a worker's single job of longest employment. This allows a longer exposure history, although one not necessarily representative of a working lifetime. Finally, occupational title risk assessment was restricted to major occupational groups. The NCHS-OHS survey, while large, is insufficient to characterize detailed risks for over 90% of 502 job titles included in U.S. Bureau of the Census listings, a major study limitation.

Evaluation of Biomechanical Risks

Recall bias may affect self-reported biomechanical exposure data. For example, cases might unconsciously (or consciously, for potential gain) inflate reports of stressor variables believed to be injury related. Conversely, healthy workers may under-estimate risks. Such biases could produce false positive associations. The ''common instrument fallacy,'' survey reporting bias resulting from collecting self-reported data for independent and dependent variables in the same instrument, is another theoretical concern, yet not always observed in practice [Katz et al., 1996]. Such biases are less likely here. NHIS-OHS was presented to interviewees as an impartial survey designed to collect nationally representative information on the currently employed, and financial gain wasn't involved. Biomechanical exposure data was collected in a preliminary job history section that preceded and was separate from injury data collection. Data on prior hand fractures and lifetime arthritis prevalence were

collected to control for potential non-occupational confounding. Neither interviewers nor respondents had any knowledge of the current hypothesis, which wasn't under consideration when the survey instrument was developed. Finally, there is not a strong a priori belief among workers or medical professionals that hand or wrist arthritis is attributable to the workplace.

Workplace biomechanical risks are assessed by psychophysical measure, the generally employed method in large population surveys. The questions employed, however, have no prior validation. There is a consensus that self-reports of physical tasks may be satisfactory at a dichotomous level (ever, never exposed), but less valid for further quantification [Pope et al., 1998]. This is considered especially true for complex load bearing work [Ainsworth et al., 1993; Burdorf, 1995], but is not always the case [Philippaerts and Lefevre, 1998].

The survey's two questions on biomechanical risks (repetitive hand and wrist bending, hand held vibrating tools), may not constitute a complete set of pertinent biomechanical risks for hand-wrist arthritis. Clinical literature identifies pinch grip [Hadler et al., 1978], power grip [Williams et al., 1987], and impact loading [Felson, 1994, 1999] as the principal pertinent biomechanical risks for hand-wrist arthritis. Theoretically, translational forces applied off center of a joint axis may lead to eccentric loading, joint instability, and arthritis [Turner, 1989]. None of these factors could be directly analyzed in the present study. Also, the NHIS-OHS vibration survey question didn't include detail on grip force, tool weight, impact loading, or vibration frequency (a selective risk for vibration injury).

CONCLUSION

The present analysis of the U.S. NHIS-OHS data set is an examination of general arthritis prevalence and workplace risk factors. It was, unfortunately, not possible to study a complete range of biomechanical factors thought pertinent to hand-wrist arthritis risk, nor could one adequately assess the risks for many individual U.S. occupations. Nevertheless, estimates of national prevalence of mild to moderately severe hand-wrist arthritis in the general working population were made. Moderately strong statistical associations between hand-wrist arthritis, specific occupations and industries, and individual workplace biomechanical factors were found. A dose response relationship between workplace biomechanics and hand arthritis is also seen in the data, while adjusting for potential confounders. There is consistency with previous research and biologic plausibility for a connection between workplace risks and hand arthritis. These findings collectively support the hypothesis that workplace hand-wrist arthritis can be a ''repetitive strain injury.'' If confirmed, then current estimates of the prevalence of repetitive strain disorders would have to be increased by at least an order of magnitude, a situation with major public policy implications. The use of self-reported data, lack of diagnostic specificity, and our cross sectional study design, however, are all major limitations on causal and temporal inference. Also, the observed occupational risks may represent true etiologic factors, or aggravation of preexisting non-occupational conditions. While the results must be considered hypothesis generating, the findings, however interpreted, appear to have general Public Health significance, given the wide prevalence of hand-wrist arthritis, and the potential for prevention through workplace ergonomic risk factor reduction.

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