Work-Related Carpal Tunnel Syndrome (WR-CTS) in Massachusetts, 1992–1997: Source of WR-CTS, Outcomes, and Employer Intervention Practices

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Background *The Massachusetts Sentinel Event Notification System for Occupational Risks (MASS SENSOR) receives reports of work-related carpal tunnel syndrome (WR-CTS) cases from (1) workers' compensation (WC) disability claims for 5 or more lost work days; and (2) physician reports (PR).*
Methods *From 1992 through 1997, 1,330 WC cases and 571 PR cases completed follow-back surveys to provide information on industry, occupation, attributed source of WR-CTS, outcomes, and employer intervention practices.*
Results *Sixty-four percent of the respondents had bilateral CTS and 61% had surgery, both of which were proportionally more frequent among WC cases. Office and business machinery was the leading source of WR-CTS (42% of classifiable sources) in every economic sector except construction, followed by hand tools (20%). Managers and professional specialty workers were the most likely to report employers' interventions and were up to four times more likely to report equipment or work environment changes than higher risk groups.*
Conclusions *State-based surveillance data on the source of WR-CTS provided valuable information on how and where to implement interventions. New occurrences of WR-CTS are likely, especially in the highest risk industries where very few cases reported primary prevention measures (e.g., changes to equipment or work environment) implemented by their employers.* Am. J. Ind. Med. 45:139–152, 2004. *© 2004 Wiley-Liss, Inc.*

***KEY WORDS:* work-related carpal tunnel syndrome; surveillance; source; outcomes; interventions**

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common nerve entrapment disorder of the upper extremities [Stevens et al., 1988]. Each year close to one million people may develop CTS that requires medical care and leaves them temporarily disabled [Tanaka et al., 1995]. Approximately 50% of all medically diagnosed CTS may be work-related [Cummings et al., 1989; Tanaka et al., 1995]. In the workplace, repetitive and forceful exertion of the hand and wrist and segmental vibration are associated with the development of CTS [Bernard, 1997; Viikari-Juntura and Silverstein, 1999].

Since work-related CTS (WR-CTS) is a preventable disorder, up-to-date information about the occupations,

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industries and circumstances in which workers develop CTS is essential to establish research priorities and target prevention efforts. In a study to determine the feasibility of using Massachusetts workers' compensation (WC) records for surveillance of work-related CTS [Korrick et al., 1994], 88% of disability claims for CTS were confirmed by a physician's diagnosis in the medical records. In 1992, the Massachusetts Department of Public Health (MDPH) established a surveillance system for WR-CTS using two data sources: WC disability claims and physician cases reports [MDPH, 1992; Korrick et al., 1994].

Between March 1992 and June 1997, 4,836 cases of WR-CTS were ascertained by this surveillance system [Davis et al., 2001], with only 6% identified by both data sources. Cases from physician reports (PR) were more likely to be male and to be employed in manufacturing than WC cases. While physician reporting helped to identify a substantial number of "cluster" worksites (employers with three or more reported cases), it appeared to be incomplete and differential by medical specialty, with more complete reporting by corporate health care providers. Still unanswered is whether PR cases were reported earlier in the disease process and therefore at a less severe stage than WC cases.

The present study uses additional information obtained from a follow-back survey of WR-CTS cases identified by the MDPH surveillance system to: (1) characterize the tools and equipment reported to contribute to WR-CTS, the outcomes of WR-CTS, and employer intervention practices; and (2) examine differences in outcomes and employer interventions between WC and PR cases.

METHODS

Surveillance Cases

The Massachusetts Sentinel Event Notification System for Occupational Risks (MASS SENSOR) identifies cases of WR-CTS using (1) WC disability claims for 5 or more lost work days; and (2) PR of individuals with confirmed or suspected WR-CTS. The surveillance data sources are described in more detail elsewhere [Davis et al., 2001].

A total of 4,836 WR-CTS cases were identified by the surveillance system between July 1992 and June 1997: 3,609 cases reported were identified through WC, 943 through PR, and 284 by both sources. A total of 3,474 cases were selected for follow-back interviews. These were all PR cases (n = 943), a random sample of WC cases ascertained in 1994 and the first quarter of 1995 (n = 332), and all WC cases ascertained between August 1995 and June 1997 (n = 2,199).

Cases of WR-CTS were divided into two groups for analysis. The first group included all cases identified through the compensation system ("WC cases"), whether or not they were also reported by a physician. The second group was comprised of those cases identified exclusively through PR ("PR cases").

Data Collection and Coding Procedures

For all cases, information related to industry and occupation were extracted from the questionnaire response and from the other available data. These were coded according to the 1987 Standard Industrial Classification Manual [Office of Management and Budget, 1987] and the 1990 Bureau of Census Alphabetical Index of Industries and Occupations [U.S. Bureau of Census, 1992], respectively.

Interviews were conducted from July 1992 through December 1997. The survey instrument consisted of 29 questions covering: case demographics; occupation, employer and job duties at the onset of symptoms; the "source" (particular task, tool, or machinery believed by the worker to have significantly contributed to hand/wrist problems); outcomes of bilateral disease, surgical treatment, and lost work time; and employer interventions, including training on the causes and prevention of WR-CTS and job changes following case onset such as a job transfer, job rotation, light duty, more rest breaks, or environmental changes such as new equipment or tools. The questionnaire was pilot-tested before use on a sample of six WR-CTS cases.

Initially, between July 1992 and April 1993, the questionnaire was administered by trained telephone interviewers (n = 80). After April 1993, to increase the interview contact rate, the questionnaire was mailed to cases indentified for follow-up. Non-respondents received a second mailing 3 weeks after the first mailing. To facilitate WR-CTS cases for whom writing was painful or who preferred to answer the questionnaire by telephone, the questionnaire cover letter provided the option of calling a toll-free number to arrange an interview. About 3 weeks after the second mailing, interviewers began calling non-respondents. Three attempts were made to conduct the telephone interview. If the case had an incorrect address or telephone number, could not complete the questionnaire because of language barriers, or refused to participate, the case was closed and the reason recorded. As new batches of cases needed to be called, older ones were randomly closed out before they were telephoned (n = 469) and were considered "non-respondents."

Of the 3,474 cases selected for follow-back, 2,149 (62%) completed questionnaires (Fig. 1). These included 1,547 (61%) WC cases and 602 (64%) PR cases. Respondents excluded from the analysis included those with musculoskeletal disorders other than CTS (n = 223, 7%) or with onset of CTS from traumatic events (n = 25, <1%), and those who responded to the pilot (incomplete) questionnaire (n = 6).

For the 1,895 questionnaire respondents analyzed, primary and secondary sources of WR-CTS were coded using the Bureau of Labor Statistics' Standard Occupational Injury and Illness Classification (SOIIC) coding system

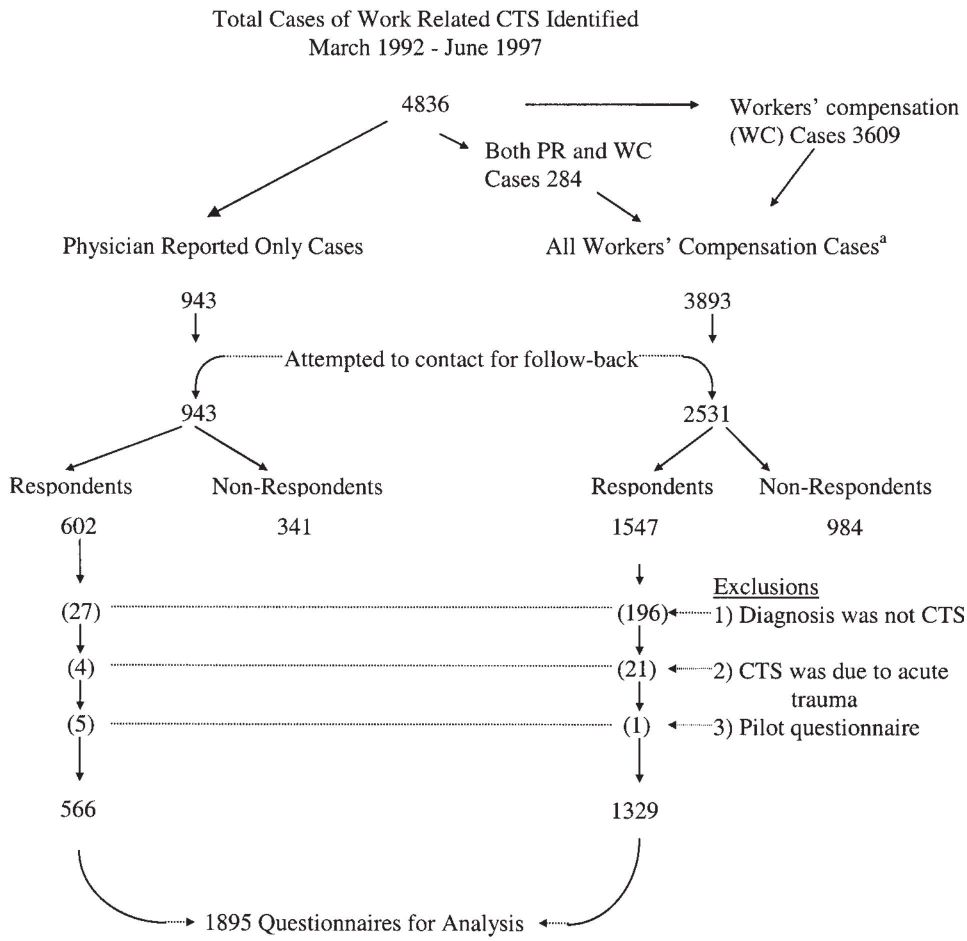

FIGURE 1. Flow diagram of all cases reported and follow-back of work-related carpal tunnel syndrome (WR-CTS) cases by data source, Massachusetts 1992–1997.

[BLS, 1992]. First and second sources of WR-CTS were compiled. The protocol for coding hand tools manufactured in both powered and non-powered varieties was as follows: if a power source was mentioned in the description or if vibration from the source was mentioned the tool was coded as a "powered hand tool;" if forceful or repetitive hand motion while using the tool and no power source was mentioned the tool was coded as a "non-powered hand tool;" if there was no supporting information on risk factors or power source the tool was coded as "power not determined."

Data Analysis

The frequencies of surgical treatment, bilateral WR-CTS, return to work, and lost work time were compared by worker age, gender, industry, occupation, and by data source (WC or PR). These were also stratified on length of time between date of injury or diagnosis and questionnaire completion date. Date of diagnosis or injury was assigned in the following order as information was available: (1) date of diagnosis from the PR; (2) self-reported date of diagnosis from interview; or (3) date of injury recorded on the WC claim.

Frequencies of employer interventions were also compared by gender, age, industry, occupation, and data source. In addition, industries and occupations were defined as high, medium, or low risk for WR-CTS based on incidence rates computed using WC cases ascertained during the study period [Davis et al., 2001]. High risk industries and occupations were defined as those with incidence rates greater than two times the statewide average annual rate of 3.4 cases per 10,000 workers. Medium risk were those with average rates between 3.4 and 6.8 cases per 10,000 workers; and low risk were those with incidence rates at or below the statewide rate. WR-CTS outcomes and employer intervention practices were compared across these risk groups to determine whether interventions were being targeted appropriately.

The chi-square test was used to compare respondents versus non-respondents and all WC versus PR cases. Standard error estimates and 95% confidence intervals (CI) around all proportions were calculated using the Wald test for binomial proportions [Anderson and Finn, 1996].

RESULTS

Respondent Characteristics

Respondents were similar to non-respondents with respect to gender and industry of employment; however, they were older than non-respondents, more likely to be employed in technical sales and administrative support occupations, and less likely to be employed as operators, fabricators, or laborers (Table I).

PR and WC cases were similar with respect to age, race, occupation, family income, and education. However, PR cases were slightly more likely to be male and to be employed in manufacturing.

Sources of WR-CTS: Tools and Equipment

There were 1,718 total classifiable WR-CTS sources cited by respondents. At least one source was identified by 1,260 respondents, a second source by 458 respondents, and 635 respondents were unable to identify a source. The distribution of respondents providing a WR-CTS source was similar to the distribution of all respondents by both occupation and industry. The proportion of respondents reporting a second source also did not vary by occupation or industry.

WR-CTS sources were rank-ordered within industry (Table II) and occupation (Table III) based on frequency of report. Office and business machinery was the leading source overall and in every industry sector except construction. Of the 1,718 total classifiable sources, 42% (n = 719) were specific types of office and business machinery: computer or computer workstation (n = 276), computer keyboard (n = 255), typing and keying with no equipment specified (n = 60), adding machines or calculators (n = 57), computer mouse (n = 41), and typewriters or word processors (n = 30).

The second most frequently cited source of WR-CTS was hand tools, which represented 20% (n = 344) of all classifiable sources. Hand tools (powered and non-powered) were the leading source of injury for the service, precision-production, craft and repair, and operators, fabricators, and laborer occupations. The hand tools most frequently cited included knives (n = 27), screwdrivers (n = 22), wrenches (n = 22), hand grinders (n = 19), hammers (n = 16), marking guns (n = 16), scissors, snaps, and shears (n = 16), and brooms, mops, and other cleaning tools (n = 15). Twice as many non-powered hand tools were cited as powered hand tools. The proportion of respondents reporting the two top sources (i.e., office and business machinery and hand tools) was similar for WC and PR cases. When restricted to the source mentioned first, the relative frequencies (at the two-digit level) were unchanged.

Outcomes: Bilateral Disease, Surgery, and Lost Work Time

CTS was reported in both hands by 1,208 respondents (64%; 95% CI 62–66%) and 1,146 (61%; 95% CI 59–63%) reported having had carpal tunnel release surgery. These outcomes did not vary by gender. The mean and median age at first surgery was 43 years. Forty-two percent of cases under 25 years had had CTS surgery.

For all respondents, the proportion with bilateral injury, surgical treatment in either one or both hands, and more than 120 days lost work time was dependent on time from diagnosis to interview. More elapsed time was associated with a greater likelihood of bilateral CTS, surgery, and no longer working for the same employer (Table IV).

The mean/median time between diagnosis and interview did not vary by industry or occupation. The construction sector had the highest proportion of cases with bilateral CTS (75%, 95% CI 64–86%) and the lowest proportion of surgically treated cases (54%, 95% CI 40–67%). The precision production craft and repair occupation had the highest proportion of surgical cases (70%, 95% CI 64–76%).

The construction sector and service occupations had the highest proportions of cases losing more than 120 work days in the 12 months prior to interview (31%, 95% CI 17–48%, and 26%, 95% CI 18–34%, respectively). The public administration sector and the managerial and professional specialty occupations had the smallest proportions of cases with more than 120 lost work days (12%, 95% CI 3–21%, and 9%, 95% CI 4–15%, respectively). None of these outcomes were consistently associated with occupation or industry risk level (injury rate).

Employer Intervention Practices

A change in work practices or work environment subsequent to injury was reported by 57% (95% CI 55–59%) of respondents (Table V). Light duty was the most frequently reported employer intervention (34%, 95% CI 32–36%) while work breaks were reported least often (10%, 95% CI 9–11%).

Intervention frequency varied by gender, with 44% of men (95% CI 40–48%) and 60% of women (95% CI 57–63%) reporting at least one change in work practices or to the work environment. Respondents in the under-25 age group were much more likely than respondents in any other age group to report at least one job change (69%, 95% CI 60–78%). These differences by gender and age were also observed within strata of occupation and industry (data not shown).

TABLE I. Demographic & Employment Characteristics of Work-Related Carpal Tunnel Syndrome (WR-CTS) Cases by Response to Survey, Massachusetts, 1992–1997

	All sensor cases		Respondents		Non-respondents		Other[a]	
	N	%	N	%	N	%	N	%
Total	4,836	100	1,895	100	1,325	100	1,616	100
Source								
All WC cases	3,893	81	1,329	70	984	74	1,580	98
PR only cases	943	19	566	30	341	26	36	2
Gender								
Female	3,464	72	1,345	71	919	70	1,200	74
Male	1,333	28	538	28	392	30	403	25
Unknown	39		12		14		13	
Age[b]								
<25	309	7	97	5	113	9	99	6
25–34	1,197	25	399	21	364	28	434	28
35–44	1,445	31	565	30	408	32	472	30
45–54	1,213	26	568	30	270	21	375	24
55–64	491	10	217	12	112	9	162	10
>64	50	1	18	1	16	1	16	1
Unknown	131		31		42		58	
Industry sector								
Manufacturing	1,587	35	647	34	460	39	480	32
Services	1,236	27	513	27	312	26	411	28
Retail trade	647	14	254	14	142	12	251	17
Transportation	296	7	117	6	84	7	95	6
Finance, insur, real est.	320	7	134	7	75	6	111	7
Wholesale trade	159	3	64	3	42	4	53	4
Public administration	143	3	70	4	32	3	41	3
Construction	124	3	55	3	35	3	34	2
Agriculture	30	1	17	1	8	1	5	0
Mining	5	0	2	0	2	0	1	0
Unclassifiable	289		22		133		134	
Occupation category[b]								
Tech. sales & admin. supt.	1,471	38	703	38	354	34	414	40
Operators, fab., & laborers	1,122	29	492	27	337	33	293	28
Prec. prod., craft & repair	479	12	250	14	115	11	114	11
Managerial & prof. spec	402	10	200	11	92	9	110	11
Service	379	10	160	9	116	11	103	10
Farming, forestry, & fish	35	1	16	1	13	1	6	1
Unclassifiable	948		74		298		576	

[a]Included in this group are those never followed up (N = 1,362) and exclusions (N = 254).
[b]Difference in distributions of respondents and non-respondents by this characteristic is statistically significant ($P < 0.001$) using Pearson's χ^2 statistic.

The finance, insurance, and real estate industry led all other industries in the proportion of cases reporting at least one intervention (Table V). A high proportion of manufacturing cases also reported at least one intervention (64%, 95% CI 60–68%), but interventions in this sector were more likely to be light duty than equipment change. Job transfers and job rotations were more likely in manufacturing than in other sectors. Workers in the construction and retail trade industries were the least likely to receive any intervention, the least likely to have changes to equipment or work environment, and the least likely to receive training on the causes of CTS.

Cases employed as managers and professional specialty and in technical and administrative support occupations

TABLE II. Most Common Sources of WR-CTS Cited by Workers in Follow-Back Survey by Industry Sector; Massachusetts

Sources of injury[a]	N	%[b]	Source subgroups (n)[c]
Total sources cited	1,718	100	
Manufacturing	**511**	**100**	
Office & business machinery	123	24	Computer workstation (59); keyboard (43); mouse (13)
Hand tools, non-powered	61	12	Pilers, tongs (8); screwdriver (8); scissors, snaps, & shears (6)
Hand tools, powered	59	12	Hand grinders (17)
Hand tools, power not determined	35	7	Screwdriver (6)
Special process machinery	32	6	Sewing, stitching machinery (12)
Electric parts	23	5	Electric wiring (8)
Paper, books, & magazines	22	4	Sheets of paper (6)
Apparel & textiles	21	4	Blouses, shirts, dresses, trousers, skirts (6)
Containers	17	3	Boxes, crates, and cartons (6)
Metal woodworking & spec process machinery	16	3	
Other tools, instruments, & equipment	12	2	Pens and pencils (6)
Machinery, unspecified	11	2	
Services	**489**	**100**	
Office & business machinery	261	53	Computer workstation (118); keyboard (105); mouse (13); typewriter & word proc. equip. (13); calc. mach. & cash register (9)
Hand tools, non-powered	37	8	Brooms, mops, & other clean tools (11); scissors, snaps, & shears (9)
Other tools instruments & equipment	37	8	Pens and pencils (20); manual scaler (7)
Paper, books, & magazines	23	5	Sheets of paper (8); mail, letters (7)
Person other than injured worker	14	3	Health care patient or resident (11)
Containers	13	3	Pots, pans, trays (11)
Medical & surgical instruments	12	2	
Heating cooling & cleaning machinery	11	2	
Hand tools, powered	11	2	
Special process machinery	10	2	
Retail trade	**244**	**100**	
Office & business machinery	75	31	Computer workstation (24); calc. mach. & cash register (34); keyboard (15)
Food products, fresh or processed	48	20	Multiple foods or groceries (29)
Hand tools, non-powered	45	18	Knives (14); marking gun (8); scoop (6); pastry bag (6)
Special process machinery	17	7	Food slicer (10)
Containers	16	7	Pots, pans, trays (6)
Finance, insurance, & real estate	**140**	**100**	
Office & business machinery	117	84	Computer workstation (54); mouse (8); typewriter & word proc. equip (7)
Other tools instruments & equipment	9	6	Pens and pencils (9)
Public administration	**79**	**100**	
Office & business machinery	53	67	Computer workstation (30); keyboard (14)
Wholesale trade	**61**	**100**	
Office & business machinery	25	41	Computer workstation (11); keyboard (8)
Hand tools, non-powered	6	10	
Transportation, communication, and other public utilities	**48**	**100**	
Office & business machinery	50	45	Computer workstation (23); keyboard (20)
Vehicle & mobile equipment parts (nec)	11	10	
Paper, books, & magazines	10	9	Mail, letters (8)
Construction	**48**	**100**	
Hand tools, powered	19	40	Hammers/jackhammers (6)
Hand tools, non-powered	14	29	

[a]Primary & secondary sources of injury were coded using the Bureau of Labor Statistics' Standard Occupational Injury and Illness Classification (SOIIC) coding system [BLS, 1992]. This list includes two-digit source cited more than five times. Four-digit sources cited more than five times at noted in parentheses, followed by the number of times cited.
[b]Percent is computed as the proportion of sources cited within sectors.
[c]Includes four-digit source subgroups cited more than five times.

TABLE III. Most Common Sources of WR-CTS Cited by Workers in Follow-Back Survey by Industry Sector; Massachusetts

Source of injury[a]	N	%[b]	Source subgroups (n)[c]
Total sources cited	1,718	100	
Technical sales & administrative support	**737**	**100**	
Office & business machinery	529	72	Computer workstations (243); keyboards (189); calculating mach. & cash register (45); typewriter & word processing equip. (30); mouse (15)
Paper, books, & magazines	35	5	Mail, letter (16); sheets of paper (9); books (8)
Other tools instruments & equipment	30	4	Pens & pencil (22); manual scaler (5)
Food products, fresh or processed	29	4	Multiple foods or groceries (28)
Hand tools, non-powered	26	4	Marking gun (11)
Miscellaneous machinery	13	2	Telephones (2)
Containers	12	2	Boxers, crates, cartons (5)
Hand tools, power not determined	10	1	
Operators, fabricators, & laborers	**390**	**100**	
Hand tools, powered	53	14	Hand grinder (14)
Hand tools, non-powered	51	13	Scissors, snaps, & shears (6); pliers, tongs (6); knives (5); wrenches (5)
Special process machinery	31	8	
Hand tools, power not determined	25	6	Screwdriver (6); hammer (5)
Containers	22	6	Boxes, crates, cartons (22)
Apparel and textiles	22	6	Blouses, shirts, dresses, trousers, skirts (7)
Paper, books, & magazines	22	6	Sheets of paper (6)
Electric parts	18	5	Electric wiring (7)
Metal, woodworking, & specialty materials	16	4	
Vehicle and mobile equipment parts	15	4	
Highway vehicle, motorized	10	3	Truck (5)
Food products, fresh or processed	10	3	
Managerial and professional specialty	**202**	**100**	
Office & business machinery	150	74	Computer workstation (71); keyboard (51); mouse (20); calculating mach. & cash register (8)
Other tools instruments & equipment	17	8	Pens & pencils (16)
Bottles	6	3	Pill bottles (6)
Precision products, fresh or processed	**170**	**100**	
Hand tools, non-powered	43	25	Pastry bag (6); screwdriver (6)
Hand tools, powered	39	23	
Hand tools, power not determined	29	17	Screwdriver (6); hammer (5)
Services	**142**	**100**	
Hand tools, non-powered	44	31	Knives (14); brooms, mops, & other cleaning tools (13); scissors, snaps, & shears (7)
Food products, fresh or processed	18	13	
Special process machinery	14	10	Food slicers (11)
Containers	13	9	Pots, pans, & trays (11)
Heating cooling & cleaning machinery	11	8	
Other tools instruments & equipment	11	8	Cooking & eating utensils except knives (5)
Person other than injured worker	10	7	Health care patient or resident (8)

[a]Primary & secondary sources of injury were coded using the Bureau of Labor Statistics' SOIIC coding system [BLS, 1992]. This list includes two-digit source cited more than five times. Four-digit sources cited more than five times are noted in parentheses, followed by the number of times cited.
[b]Four-digit sources listed in more than one occupation are noted in bold.
[c]Percentages are computed as the proportion of all sources cited within an occupation category.

TABLE IV. Injury Impact Stratified by Time Between Diagnosis and Survey, WR-CTS Cases, Massachusetts, 1992–1997

			Time elapsed between date of diagnosis and date of survey																
			0–>6 months				6–>12 months				12–>18 months				>18 months			
	Overall		PR only		All WC		PR only		All WC		PR only		All WC		PR only		All WC	
	N[a]	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	1,895	100	178	100	283	100	204	100	519	100	111	100	238	100	42	100	263	100
Bilateral disease																		
CTS in one hand	680	36	96	55	108	38	93	46	169	33	47	42	76	32	8	19	59	22
CTS in both hands	1,208	64	78	45	173	62	110	54	350	67	64	58	162	68	34	81	204	78
Unknown	7		4		2		1		0						0		0	
Surgical treatment																		
Yes	1,146	61	53	30	146	52	72	35	382	74	49	44	175	75	20	48	216	83
No	736	39	124	70	135	48	131	65	134	26	62	56	59	25	22	52	45	17
Unknown	13		1		2		1		3		0		4		0		2	
Bilateral surgery treatment																		
Yes	407	22	6	3	53	19	13	6	153	30	6	5	62	26	6	14	100	38
No	1,465	78	171	97	228	81	190	94	363	70	105	95	172	74	38	86	161	62
Unknown	13		1		2		1		3						0		2	
Still employed by same employer																		
Yes	1,235	66	150	85	174	63	156	77	318	62	80	73	142	61	27	68	155	59
No	409	22	24	14	44	16	41	20	107	21	28	25	63	27	11	28	76	29
Yes but out on comp	229	12	3	2	60	22	6	3	88	17	2	2	29	12	2	5	30	11
Unknown	22		1		5		1		6		1		4		2		2	
Work days lost in 12 months prior to interview																		
Less than 5 days	293	21	59	66	23	9	44	49	45	10	31	72	22	11	8	40	52	24
5 days–6 months	803	58	23	26	193	78	38	42	281	64	9	21	124	61	8	40	117	53
Greater than 6 months	290	21	7	8	32	13	8	9	114	26	3	7	58	28	4	20	50	23
No response/no question	509		89		35		114		79		68		34		22		44	

[a]Individual columns may not add to overall because some records were missing the "date of diagnosis."

TABLE V. Employer Intervention Practices Reported by Individuals With Work-Related CTS in Follow-Back Survey, by Industry and Occupation Category, Massachusetts 1992–1997

		At least one intervention		Training on causes & prev. of CTS		Change to equip or work environ		Rotated job tasks to reduce repetition		Given light duty		Transferred to new job		Provided more rest breaks	
	N_{total}[a]	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	1,895	1,046	57	495	27	522	29	266	14	622	34	201	11	190	10
Industry sector															
Financ., insur., real est	134	91	69	51	39	77	58	20	15	39	30	6	5	23	17
Manufacturing	647	407	64	204	32	169	27	121	19	254	40	120	19	66	10
Services	513	288	58	136	28	178	36	68	14	163	33	29	6	62	12
Wholesale trade	64	37	58	14	22	15	23	7	11	27	42	5	8	10	16
Public admin.	70	39	56	17	27	24	34	4	6	18	26	4	6	6	9
Transportation	117	49	43	25	22	22	19	12	11	31	27	6	5	8	7
Retail trade	254	101	41	35	14	28	11	27	11	67	27	26	11	9	4
Construction	55	17	34	4	8	4	8	3	6	12	24	5	10	4	8
Agriculture[b]	17	8	—	4	—	1	—	4	—	4	—	0	—	1	—
Mining[b]	2	1	—	1	—	0	—	0	—	1	—	0	—	0	—
Non-classifiable	22	8		4		4		0		6		0		1	
Occupation category															
Managerial & prof. spec.	200	129	67	89	46	102	53	20	10	51	27	13	7	28	15
Tech sales & admin. spt	703	415	60	219	32	282	41	98	14	219	32	40	6	89	13
Oper., fab., laborers	492	262	54	92	19	69	14	81	17	180	37	87	18	38	8
Prec. prod. craft & repair	250	121	51	53	22	31	13	39	16	87	36	35	15	19	8
Service occupations	160	70	45	20	13	17	11	12	8	51	33	13	8	11	7
Farming, forest, fish[b]	16	7	—	1	—	0	—	12	—	3		1	—	1	—
Non-classifiable	74			21		48		13		31		12		4	

[a]N_{total} includes all cases interviewed for each industry sector and occupation category. Cases with missing information were excluded in calculating percentages.
[b]Percentages not calculated for industry sectors or occupation categories where less than 20 people were interviewed.

were more likely to report equipment or work environment changes and more likely to have received training than any other occupational group. Workers in the service occupations were among the least likely to receive interventions overall and to receive training.

Primary interventions such as change in equipment or environment and training on the causes of WR-CTS were least likely to be reported in the highest risk industries and occupations (Table VI). Instead, secondary interventions such as work breaks, light duty, and transferal to a new job (secondary interventions) were more often reported in these settings.

Differences Between WC and PR Cases

The time elapsed from diagnosis until report to DPH was much longer for WC than PR cases (mean/median: 333/167 days vs. 72/14 days, respectively), and consequently the time elapsed from diagnosis to interview was longer (mean/median: 444/296 days vs. 288/236 days).

PR cases overall had less bilateral CTS (53% vs. 68%, $P < 0.001$), less surgical treatment (37% vs. 71%, $P < 0.001$), and less time away from work than WC cases (Table IV). Over 70% of WC cases (n = 938) were surgically treated and approximately 30% were surgically treated in both hands. WC cases were disproportionately more likely to report bilateral surgery and to be out of work on compensation at the time of interview, even within strata of time from diagnosis to interview.

Among surgical cases, the mean/median time from diagnosis to surgical treatment for WC cases was 246/108 days (n = 782), compared with 115/62 days for PR cases (n = 118). Of the WC cases surgically treated in both hands, 80% had the second surgery within 6 months of surgery on the first hand.

Similar proportions of PR cases and WC reported at least one intervention of any type and reported training on the causes and prevention of CTS. However, PR cases were more likely to have received new equipment or had changes made in the work environment than WC cases (36% vs. 26%, $P < 0.0001$).

DISCUSSION

This descriptive study, based on questionnaire responses of close to 2000 WR-CTS cases identified through statewide surveillance in Massachusetts, indicates that many workers with CTS experienced severe outcomes: 64 % had CTS in both hands, 61% had surgery on at least one hand, and over 30% had surgery in both hands. WR-CTS cases identified through WC disability claims experienced longer lead times for treatment and more severe outcomes than cases identified exclusively through physician case reports. Computers and computer workstations were the most frequently cited source of WR-CTS in Massachusetts, according to the cases themselves. Managers and professionals had better access to accommodations, particularly changes to equipment or the work environment, than did non-professionals after experiencing symptoms in the hands and wrists.

TABLE VI. Employer Intervention Practices Reported by Individuals With Work-Related CTS in Follow-Back Survey, by Occupation and Industry Risk Category*

		Training on the causes and prev. of CTS		Change to equipment		Change to work environment		Rotated job tasks to reduce repetition		Given light duty		Transferred to new job		Provided more work breaks	
	N_{tot} [a]	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	1,895	495	27	1,780	14	1,844	23	266	14	622	34	201	11	190	10
Occupation risk category															
Low risk	633	176	28	82	14	148	25	57	9	184	30	35	6	62	10
Medium risk	573	138	25	77	14	146	26	87	16	187	34	64	11	60	11
High risk	590	156	27	74	13	110	19	107	18	212	36	86	15	63	11
Industry risk category															
Low risk	774	177	24	102	14	192	26	95	13	224	30	52	7	81	11
Medium risk	372	121	34	51	14	112	31	50	14	126	35	24	7	48	13
High risk	678	180	27	87	13	104	16	116	17	256	38	123	19	55	8

*High risk industries and occupations were defined as those with incidence rates greater than two times the statewide average annual rate of 3.4 cases per 10,000 workers. Medium risk industries and occupations were those with average rates between 3.4 and 6.8 cases per 10,000 workers; and low risk industries and occupations were those with incidence rates at or below the statewide rate.

[a] N_{tot} includes all cases interviewed for each industry and occupation risk category. Cases with missing information were excluded in calculating percentages. Cases not classifiable into an occupation or industry group were excluded from the risk analysis.

Although approximately 40% of the PR cases reported they had lost more than 5 days of work because of their WR-CTS, there was only a small overlap between PR and WC cases, which suggests that the magnitude of WR-CTS is far greater than that indicated solely by more readily available WC data. Several other studies have shown minimal overlap in reporting of work-related injuries and illness from WC claims and medical providers, indicating substantial underreporting in both data sources [Park et al., 1992; Maizlich et al., 1995; Silverstein et al., 1997; Biddle et al., 1998; Pransky et al., 1999].

Source of Injury

Previous surveillance studies have reported on the incidence of WR-CTS by industry and occupation [Franklin et al., 1991; Tanaka et al., 1995; Silverstein et al., 1998; Davis et al., 2001]; this study adds information on source of WR-CTS within industry and occupation. Aggregate surveillance data on source of WR-CTS can be very useful for identifying particular tasks, tools or equipment that might cause or contribute to CTS in specific industries, occupations or work environments. In this study, office and business machinery represented 42% of all classifiable sources and was the leading source of WR-CTS in every sector but construction. Computers or computer workstations were cited most frequently (n = 276), which is consistent with other reports indicating an association between repetitive motion injuries and keyboard typing or computer terminals [Punnett and Bergqvist, 1997; BLS, 1997]. Whereas it is well documented that the highest rates of WR-CTS are in the manufacturing industry [Franklin et al., 1991; Maizlich et al., 1995; Tanaka et al., 1995; BLS, 1997; Davis et al., 2001], the finding here that office and business machinery was mentioned most often by manufacturing workers is new and merits attention. It is clear from these results that prevention efforts in manufacturing should focus not only on production floor operations, but also on computer usage, which may now take place on the factory floor as well as in offices.

The proportion of office and business machinery sources cited in this study is consistent with the BLS Annual Survey of Occupational Injuries and Illnesses 1994–1997, where 42% of WR-CTS cases indicated the type of equipment involved (‘‘secondary source’’) to be some type of office and business machinery [Davis et al., 2004]. This finding is compelling and indicates there is no observable bias in the way that people self-report the source of WR-CTS, compared with the way employers report the source of WR-CTS (BLS survey). This finding is also consistent with the high counts and high incidence rates of WR-CTS in various office occupations (e.g., insurance adjusters, data entry keyers) in Massachusetts [Davis et al., 2001].

Among those office workers who reported two sources of WR-CTS, when the keyboard was listed as the first source the mouse was often listed second, and vice-versa. Since both devices are often used together, this suggests that these workers are experiencing a general problem in the interface with the work environment that manifests itself with each item of office machinery used. In addition, the pathway from computer use to WR-CTS may be mediated by more general aspects of the work environment, such as static postures, psychological demands, and workload [Punnett and Bergqvist, 1997] that should also be accounted for in developing prevention strategies.

In the highest risk occupation groups (operators, fabricators, & laborers and precision production craft and repair), hand tools were cited most often as the source of WR-CTS. There is clear evidence in the literature for an excess risk of WR-CTS in occupations involving heavy repetitive manual work [Hagberg et al., 1992; Bernard, 1997]. The specific hand tool listed the most often was ‘‘hand grinder.’’ Grinding, abrading, buffing, and polishing operators had the highest incidence rate of WR-CTS in Massachusetts, over eight times the overall rate [Davis et al., 2001]. This is further consistent with the evidence for the etiologic role of hand-arm vibration [Viikari-Juntura and Silverstein, 1999].

Identifying source(s) within high risk occupations, or industries provides useful information for targeting intervention efforts. At the same time, it is important to remember that the concept of ‘‘source of injury’’ originated with acute traumatic injuries, where it is relatively easy to identify the source. The ability of workers or anyone else to identify accurately the ‘‘source’’ of a gradual-onset disorder has not been demonstrated; one example is the decision of whether to attribute CTS to the keyboard, the mouse, or the entire computer workstation setup. Further research would be useful to explore how such attributions might be affected by the time from first exposure to onset and exposures to multiple risk factors (simultaneous or in sequence).

Outcomes: Surgery, Bilateral Disease, and Lost Work Time

The proportion of the WR-CTS cases in this study with surgery (61%) was notably higher than the 40% reported from Washington State WC claims data [Adams et al., 1994]. Differences in case definition probably account for this, in that the Massachusetts WC cases, which comprised 72% of the cases in this study, were limited to cases filing claims for 5 or more lost workdays, whereas the Washington State study included cases identified through both ‘‘medical only’’ and lost-time claims.

The lack of correlation between observed WR-CTS rates and indicators of CTS severity suggests that the sector-specific data in these surveillance systems are differentially influenced by factors other than the etiologic exposures themselves. This discrepancy could result from early interventions by employers, but we did not find such actions more common in the higher risk sectors. Thus the data suggest evidence of differential under-reporting by sector, which could be explained by socioeconomic or other differences among employees that affected the many steps between CTS onset and reporting or seeking care [Azaroff et al., 2002].

For example, respondents working in the construction sector were more likely to have bilateral injury and prolonged work absences (although less likely to have surgical treatment for CTS) than people working in other industries. Overall, construction workers had only average rates despite their physically strenuous work and high rates reported elsewhere [Silverstein et al., 1998]. They also reported disproportionately few employer interventions. The work organization of construction and the culture that surrounds it [Moir et al., 2003] could easily influence both CTS reporting and workers seeking surgical treatment.

Although WC and PR cases were similar with regard to age, gender, race, family income, education, and occupation, WC cases reported more bilateral disease, surgery and lost work time than PR cases. This is not surprising in that workers' must have lost at least 5 days of work due to their condition to file a lost work time claims, whereas physicians are required to report all cases, regardless of work time lost. However, the differences were striking even after stratification on time since onset. These findings suggest that using lost time WC claims, as a surveillance data source will identify mostly more severe cases. At the same time, the large number of PR cases who had lost at least 5 workdays (40%) and had had surgery (37%) is noteworthy and indicates that many severe cases will be missed relying solely on lost work time WC claims.

Several studies have suggested that individuals with CTS who file WC claims stay out of work longer following surgical treatment than individuals who do not file claims, especially for claims involving an attorney [Al-Qattan et al., 1994; Higgs et al., 1995; Katz et al., 1997, 1998]. The question remains as to whether a person stays out longer following surgery in order to increase the likelihood of a WC award, or whether those who seek compensation have already progressed to a more severe stage than other cases. Herbert et al. [1999] have shown that there are often long delays between a physician request for necessary medical treatment for CTS and WC authorization.

WC cases by definition are workers with CTS presumably ''caused'' by workplace factors, whereas non-WC cases are CTS presumably ''caused'' by factors outside of work or by workplace factors where a WC claim is not established because the injury is not severe enough (medical only), or where treatments/accommodations are made without the need for a WC settlement. Therefore, identified WC cases might have inherently had more difficulty returning to the workplace where they developed WR-CTS.

Feuerstein et al. [1999] reported that the primary reasons for CTS patients not returning to work following treatment were safety factors at the work site and a perceived inability to perform their job. In a study of successfully awarded WC CTS surgical claimants in Washington State, no association was reported between severity of WR-CTS prior to surgical treatment and postoperative duration of disability [Adams et al., 1994]. The authors suggested that psychosocial, medical, and work-related administrative factors predicted duration of disability better than biologic severity. These reports highlight the need to examine multiple factors in evaluating medical outcomes and the complexity of case progression over time [Baldwin et al., 1996].

Employer Intervention Strategies

While more than half of the WR-CTS cases employed in finance, insurance, and real estate were provided changes to their equipment or work environment, the same was done for only 27% of workers employed in manufacturing. This may reflect differences in costs and availability of interventions for certain industries, occupations, or work environments, or differences in employers' perceptions of feasibility or justification. Changes to office equipment such as the procurement of adjustable furniture may be easier to implement than changing a manufacturing process such as the layout of an assembly line workstation. In a recent review article of intervention studies for the primary prevention of WR-CTS the authors found multiple studies evaluating alternative keyboards, computer mouse design, and keyboard support systems, but only one study evaluating tool redesign [Lincoln et al., 2000].

Workers employed in manufacturing were more likely than workers in any other industry to be given light duty. Light duty as an intervention strategy may be a way for employers to maintain their scheduled output and may appear more feasible to manufacturing employers than workstation changes, as noted above. However, this type of intervention may also increase the burden on the injured worker to return to work prematurely due to reduced wages. Also, if the work environment and work organization remain unchanged, there is a greater likelihood that re-injury will occur when the worker resumes full duty, or that another worker who is placed in the same job will become injured.

Managers and professional specialty workers were the most likely to report interventions overall and were up to four times more likely to report equipment or work environment changes than higher risk occupation groups such as precision production craft and repair and operators, fabricators, and laborers. The low WR-CTS incidence rates reported for managers and professional specialty workers [Davis et al., 2001], in addition to a high report of interventions, suggests that this group has better access to engineering changes, proper education on how to set up a computer workstation to reduce exposures, and/or work organizational changes such as number of hours typing, time flexibility in pacing and scheduling work tasks, and so on. It is not obvious why more interventions were reported by women and younger workers, since these differences could not be explained by the effects of occupation such as those noted above. These findings remain to be explored in future research.

Primary prevention measures, which eliminate or reduce exposure (engineering and environmental controls), were reported less often by workers who were working in the highest risk industries. If employers only attempt to reduce exposures by implementing secondary interventions such as transferring the injured worker to a new job or assigning him/her to light duty, without changing the work environment itself, the exposures remain high risk for the next employee who takes over the job and new occurrences of WR-CTS can be expected.

Study Strengths and Weaknesses

Among the strengths of this study were the large number of interviews conducted and the fact that respondents were representative of all MASS SENSOR cases with respect to demographic and occupational characteristics. Also, the use of two alternative data sources for work-related CTS provided insight as to the limitations of each and a deeper understanding of the severity of WC indemnity cases in Massachusetts.

There were several limitations to this study. Using date of diagnosis as a reference point can be problematic in a chronically and gradually appearing illness. Also, results were dependent on the point in time in the history of the case the interview was completed. Length of time between diagnosis and interview ranged from less than 1 month to more than 18 months. Cases falling in the latter end of this spectrum were more likely to report CTS in both hands, surgical treatment, and greater lost work time. This may affect the comparison of PR and WC cases because PR cases were interviewed much earlier after diagnosis than WC cases (median 236 days vs. 296 days; mean 288 vs. 444, respectively). However, a comparison of PR and WC cases interviewed more than 18 months post diagnosis still indicated differences with respect to surgery and lost work time. An absence of any data on temporal sequence of accommodations and outcomes prevented us from making any conclusions about whether or not specific accommodations were successful.

Self-report of sources, where the system requires a work etiology for compensation, may generate impetus for bias toward acute rather than chronic factors or at least for some attribution even if the respondent does not know the source. Analysis of the source of injury was limited to the first two occurrences in the response, although sometimes there were more than two sources listed. Thirty percent of the respondents were unable to list a source, indicating that the list presented may not be comprehensive, that WR-CTS may be caused by multiple factors in the work environment, or that many workers may not feel able to attribute a cause to a disorder of gradual onset. It would have been better to ask the respondent to prioritize the primary and secondary source (if applicable) and to specify the power source of tools mentioned.

Another limitation is that the generalizability of results depends on the representativeness of cases reported through WC and by physicians. WC cases reflect the types of workers who successfully establish a claim for their CTS, and PR cases represent workers who see physicians that follow reporting requirements. Corporate medical providers are in a position to detect disease in the early stages and may be more likely to intervene [Davis et al., 2001]; in fact, PR cases in this dataset were more likely to report primary interventions by their employers. Thus, the marked differences between PR and WC cases likely reflect not only differences in stages of CTS, but also in pathways to identification [Azaroff et al., 2002].

CONCLUSION

The present findings on the extent of bilateral disease, surgical treatment and lost work days among individuals with WR-CTS underscore the importance of prevention to reduce the human and economic burden associated with this condition. Cases identified only through PR had less severe outcomes than those identified through WC claims in Massachusetts, even accounting for the greater time lapse between diagnosis and interview for the WC cases. However, many PR cases also had severe outcomes; thus a surveillance system based on the more readily available WC data would fail to capture a substantial proportion of preventable disability. Findings regarding equipment and tools reportedly associated with CTS provided valuable information in targeting intervention efforts. The frequent attribution of CTS to computers and related devices is consistent with evidence linking WR-CTS and office work.

While a substantial proportion of employers had implemented changes in equipment or work environment, over 40% of the respondents reported that no changes had been made and only 27% reported training on the causes and prevention of WR-CTS. When interventions were implemented a larger proportion of employers implemented secondary interventions instead of primary interventions. This was especially evident in high risk industries and occupations. Thus, important opportunities for primary and secondary prevention are still being lost.

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REFERENCES

Adams ML, Franklin GM, Barnhart S. 1994. Outcome of carpal tunnel surgery in Washington State workers' compensation. Am J Ind Med 25:527–536.

Al-Qattan MM, Bowen V, Manktelow RT. 1994. Factors associated with poor outcome following primary carpal tunnel release in non-diabetic patients. J Hand Surg (European volume, 1994) 19B:622–625.

Anderson TW, Finn JD. 1996. The new statistical analysis of date. Springer–Verlag, 712 p.

Azaroff L, Levenstein C, Wegman DH. 2002. Occupational injury and illness surveillance: Conceptual filters explain underreporting. Am J Pub Health 92:1421–1429.

Baldwin ML, Johnson WG, Butler RJ. 1996. The error of using return to work to measure the outcomes of health care. Am J Ind Med 29:632–641.

Bernard B. 1997. Musculoskeletal disorders and workplace factors: A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. Cincinnati: Department of Health and Human Services, National Institute of Occupational Safety and Health. DHHS (NIOSH) Pub No. 97–141.

Biddle J, Roberts K, Rosenman K, Welch E. 1998. What percentage of workers with work-related illnesses receive workers' compensation benefits? J Occup Environ Med 40:325–331.

Bureau of Labor Statistics. 1992. Occupational Injury and Illness Classification Manual. Washington, DC: US Department of Labor, Bureau of Labor Statistics.

Bureau of Labor Statistics. 1997. Background information on days away from work cases, 1995. Bureau of Labor Statistics, US Department of Labor: Washington, DC.

Cummings H, Maizlich N, Rudolph L, Dervin K, Ervin A. 1989. Occupational disease surveillance: Carpal tunnel syndrome. Morb Mortal Wkly Rep 38:485–489.

Davis L, Wellman H, Punnett L. 2001. Surveillance of work-related carpal tunnel syndrome in Massachusetts, 1992–1997: A report from the Massachusetts sentinel event notification system for occupational risks (SENSOR). Am J Ind Med 39:58–71.

Davis L, Wellman H, Hart J, Cleary R, Gardstein B, Sciuchetti P. 2004. A comparison of data sources for the surveillance of work-related carpal tunnel syndrome in Massachusetts. Am J Ind Med (in press).

Feuerstein M, Burrell LM, Miller VI, Lincoln A, Huang GD, Berger R. 1999. Clinical management of carpal tunnel syndrome: A 12-year review of outcomes. Am J Ind Med 35:232–245.

Franklin GM, Haug J, Heyer N, Checkoway H, Peck N. 1991. Occupational carpal tunnel syndrome in Washington State. Am J Public Health 81:741–746.

Hagberg M, Morganstern H, Kelsh M. 1992. Impact of occupations and job tasks on the prevalence of carpal tunnel syndrome. Scand J Work Environ Health 18:337–345.

Herbert R, Janeway K, Schechter C. 1999. Carpal tunnel syndrome and workers compensation among an occupational clinic population in New York State. Am J Ind Med 35:335–342.

Higgs PE, Edwards D, Martin DS, Weeks PM. 1995. Carpal tunnel surgery outcomes in workers: Effect of workers' compensation status. J Hand Surg 20A:354–360.

Katz JN, Keller RB, Fossel AH, Punnett L, Bessette L, Simmons BP, Mooney N. 1997. Predictors of return to work following carpal tunnel release. Am J Ind Med 31:85–91.

Katz JN, Lew RA, Bessette L, Punnett L, Fossel AH, Mooney N, Keller RB. 1998. Prevalence and predictors of long term work disability due to carpal tunnel syndrome. Am J Ind Med 33:543–550.

Korrick S, Rest KM, Davis LK, Christiani DC. 1994. Use of state workers' compensation data for occupational carpal tunnel syndrome surveillance: A feasibility study in Massachusetts. Am J Ind Med 25:837–850.

Lincoln AE, Vernick JS, Ogaitis S, Smith GS, Mitehell CS, Agnew J. 2000. Interventions for the primary prevention of work-related carpal tunnel syndrome. Am J Ind Med 18:37–50.

Maizlich N, Rudolph L, Dervin K Sankaranarayan M. 1995. Surveillance and prevention of work-related carpal tunnel syndrome: An application of the sentinel events notification system for occupational risks. Am J Ind Med 27:715–729.

Massachusetts Department of Public Health. 1992. Reportable diseases and isolation and quarantine requirements. In Massachusetts Department of Public Health: "Code of Massachusetts Regulations: 105 CMR 300.000."

Massachusetts Department of Public Health. 1997. Hands at work newsletter: Carpal tunnel syndrome in young workers. Massachusetts Department of Public Health. Summer 1997.

Moir S, Paquet V, Punnett L, Buchholz B. 2003. Making sense of highway construction: A taxonomic framework for ergonomic exposure assessment and intervention research. Appl Occ Env Hyg 18:256–267.

Office of Management and Budget. 1987. Standard Industrial Classification Manual, 1987. Washington, DC: Office of Management and Budget.

Park RM, Nelson NA, Silverstein BA, Mirer FE. 1992. Use of medical insurance claims for surveillance of cumulative trauma in the auto industry. J Occup Med 34:731–737.

Pransky G, Snyder D, Denby A, Himmelstein J. 1999. Under-reporting of work-related disorders in the workplace: A case study and review of the literature. Ergonomics 42:171–182.

Punnett L, Bergqvist U. 1997. Visual display unit work and upper extremity musculoskeletal disorders: A review of epidemiological findings. Solna Sweden: National Institute of Working Life, Arbete och Hälsa 199716.

Silverstein BA, Stetson DS, Keyserling WM, Fine LJ. 1997. Work-related musculoskeletal disorders: Comparison of data sources for surveillance. Am J Ind Med 31:600–608.

Silverstein BA, Welp E, Nelson N, Kalat J. 1998. Claims incidence of work-related disorders of the upper extremities: Washington State, 1987–1995. Am J Public Health 88:1827–1833.

Stevens JC, Sun S, Beard CM, O'Fallon WM, Kurland LT. 1988. Carpal tunnel syndrome in Rochester, Minnesota, 1961 to 1980. Neurology 38:134–138.

Tanaka S, Wild DK, Seligman PJ, Halperin WE, Behrens VJ, Putz-Anderson V. 1995. Prevalence and work-relatedness of self-reported carpal tunnel syndrome among U.S. workers: Analysis of the occupational health supplement data of 1988 national health interview survey. Am J Ind Med 27:451–470.

U.S. Bureau of Census. 1992. Alphabetical index of industries and occupations. Washington, DC: US Government Printing Office.

Viikari-Juntura E, Silverstein BA. 1999. Role of physical load factors in carpal tunnel syndrome. Scand J Work Environ Health 25:163–185.