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ORIGINAL ARTICLE

Natural History and Predictors of Long-Term Pain and Function Among Workers With Hand Symptoms

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Abstract

Objective: To evaluate predictors of hand symptoms and functional impairment after 3 years of follow-up among workers with different types of hand symptoms including carpal tunnel syndrome (CTS). Functional status and job limitations were also analyzed as key secondary objectives.

Design: Cohort design of 3 years duration.

Setting: Working population-based study.

Participants: Newly employed workers without a preexisting diagnosis of CTS (N=1107). Subjects were categorized into 4 groups at baseline examination: no hand symptoms, any hand symptoms but not CTS (recurring symptoms in hands, wrist, or fingers without neuropathic symptoms), any hand symptoms of CTS (neuropathic symptoms in the fingers and normal nerve conduction study), or confirmed CTS (CTS symptoms and abnormal nerve conduction study). Among workers with hand pain at baseline, subject and job characteristics were assessed as prognostic factors for outcomes, using bivariate and multivariate regression models.

Interventions: Not applicable.

Main Outcome Measure: The primary outcome assessed by questionnaire at 3 years was "severe hand pain" in the past 30 days.

Results: At baseline, 155 workers (17.5% of 888 followed workers) reported hand symptoms, of which 21 had confirmed CTS. Presence of hand pain at baseline was a strong predictor of future hand pain and job impairment. Subjects with confirmed CTS at baseline were more likely than workers with other hand pain to report severe hand pain (adjusted prevalence ratios 1.98 [95% confidence interval 1.11−3.52]) and functional status impairment (adjusted prevalence ratios 3.37 [95% confidence interval 1.01−11.29]). Among subjects meeting our case definition for CTS at baseline, only 4 (19.1%) reported seeing a physician in the 3-year period.

Conclusions: Hand symptoms persisted among many workers after 3-year follow-up, especially among those with CTS, yet few symptomatic workers had seen a physician.

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Hand musculoskeletal disorders, which include peripheral nerve entrapments and tendon disorders, as well as nonspecific musculoskeletal regional pain disorders,[1,2] have become one of the most significant and costly health problems in working populations.[3,4] Carpal tunnel syndrome (CTS) is a major cause of hand symptoms among the working population worldwide and is notable for its high costs related to medical treatment and work disability.[5-8] The efficacy of surgical decompression of the carpal tunnel in relieving symptoms of CTS has been well documented,[9] and some patients who avoid surgery improve spontaneously.[10-12] However, the natural history of CTS is poorly understood, particularly among patients with CTS who are not evaluated in clinical settings.[12,13]

In working populations, many workers with hand symptoms do not receive surgery or other medical treatment. A study of 418 active workers in 12 worksites reported the persistence of hand

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symptoms after 1 year.[14] Among the 62 workers with hand pain at baseline (45 with CTS defined by symptoms and nerve conduction abnormality, 17 with other disorders), 28 had persistent symptoms, and persistence of pain was predicted by initial diagnosis of CTS.[14]

We hypothesized that active workers meeting a case definition of CTS would have worse outcomes after 3 years of follow-up than workers with other categories of hand pain. To study this question, we examined a cohort of workers at the time of hire and at 3-year follow-up, and evaluated the baseline characteristics that predicted future hand pain and functional or job limitations among workers with initial hand symptoms. We also described prevalence of the outcomes at follow-up between subjects with hand symptoms and those without symptoms at baseline.

Methods

Population

This study presents data collected as part of the Predictors of Carpal Tunnel Syndrome (PrediCTS) study, an ongoing prospective study. The PrediCTS study cohort includes 1107 newly hired workers recruited from participating companies between July 2004 and October 2006. Subjects were recruited from industries with both high and low hand-intensive jobs, including construction trades, health care, manufacturing, and biotechnology. Eligible workers were at least 18 years of age and were starting a new full-time job (at least 30h/wk) or recently became benefits eligible.[15] Workers were excluded if they had a previous diagnosis of CTS or peripheral neuropathy or were pregnant at baseline.[15] The Washington University School of Medicine Institutional Review Board approved this study, and all subjects provided written informed consent prior to participation.

Data collection and measures

At the time of enrollment, subjects completed the baseline testing protocol, which included a bilateral nerve conduction test of the median and ulnar nerves at the wrist, a brief physical examination of the upper extremities, and a self-administered questionnaire. Baseline test results were mailed to all subjects; those with symptoms and nerve conduction abnormalities suggestive of CTS were encouraged to see a physician. Follow-up questionnaires were collected at 6, 18, and 36 months after baseline. The follow-up questionnaires were either mailed to subjects or distributed at apprenticeship training classes or the worksite. Subjects who failed to return questionnaires were asked to complete the survey by telephone. Study subjects were compensated for their participation in the baseline testing protocol and each follow-up questionnaire.

Baseline and follow-up questionnaires included items on personal characteristics, upper-extremity symptoms, medical care for hand/wrist disorders, and functional status.[16] The questionnaires also assessed physical work exposures, changes in work productivity and duties, and psychosocial measures such as job satisfaction and coworker/supervisor support.

List of abbreviations:

CI	**confidence interval**
CTS	**carpal tunnel syndrome**
PrediCTS	**Predictors of Carpal Tunnel Syndrome**

Symptoms of the hand and wrist were assessed using the following initial question: "In the past year, have you had recurring (repeated) symptoms in your hands, wrists, or fingers more than 3 times or lasting more than 1 week?" If yes, subjects answered questions about the location of symptoms (fingers, hands, wrists), the nature of the symptoms (ie, burning/pain, tightness/stiffness, soreness/cramping/aching, and numbness/tingling), completed a hand diagram,[17,18] and reported on symptom intensity in the last 30 days and the presence of nocturnal symptoms.

Our case definition of CTS required a combination of symptoms and abnormal median nerve conduction.[19,20] Symptoms were classified as "classic" or "probable" using modified scoring of the hand diagram described by Katz[17] and Dale[18] and colleagues. Abnormal median nerve conduction was defined as sensory latency >3.5ms (14cm) OR motor latency >4.5ms OR median-ulnar sensory latency difference of >0.5ms (14cm).[21]

Subjects were categorized according to baseline data into 4 mutually exclusive groups: symptoms of CTS (neuropathic symptoms in the median innervated fingers) without nerve conduction abnormalities, or confirmed CTS (symptoms of CTS and abnormal nerve conduction study); or other recurring symptoms in the wrist, hands, or fingers, or no symptoms in the wrist, hands, or fingers.

Outcomes

The primary outcome at 3 years was "severe hand pain," defined as hand pain within the past 30 days with a rating of 5 or higher on a scale of 0 (no discomfort) to 10 (worst discomfort imaginable). Using the same scale, "no pain" was defined as a rating of 0 and "moderate pain" was defined as a rating of 1 to 4.

Secondary outcomes included changes in functional status or job limitations due to hand/wrist pain.[22] The Levine Functional Status Scale was used for assessing functional status limitations[16]; this scale is based on subjects' self-rated ability to perform regular work duties or activities of daily living, rated on a scale from 1 (no difficulty) to 5 (cannot perform activity at all). To determine overall functional status scores at baseline and 36 months, the average of the 8 items was used. The mean differences of functional status scores between baseline and follow-up were divided by the SD of the difference to calculate effect size.[23] Subjects with an effect size of 0.8 or greater were considered positive for functional status limitations.[16] Job limitation was created as a dichotomous composite outcome that included all workers who reported a limitation attributed to hand symptoms in 1 or more of the following areas: (1) limited ability to work, (2) decreased productivity, (3) lost time from work, (4) placed on job restrictions, and a (5) change in job or employer.[24]

Analyses

Baseline subject categorization and independent variables (sex, age, level of education, severe hand pain at baseline) were assessed as prognostic factors for the outcome. Self-reported occupational exposures were taken from the 6-month questionnaire, as many workers had not yet started their new jobs at the time of the baseline examination. Based on literature review and preliminary analyses, 1 physical exposure factor and 1 psychosocial exposure factor were chosen for analysis: workers who reported tasks where they used a twisting, rotating, or screwing motion of the forearm 4 or more hours per day, and social support

scale measurement ≤22 (indicating the lowest quartile of level of social support).[25] Subjects were also asked whether they had seen a physician for the treatment of hand pain, and whether they had received surgery or a steroid injection or used a wrist brace or other treatment for CTS at any time during the study period.

We analyzed predictors of the 3 study outcomes: severe hand pain, functional status limitation, and job limitation at 3-year follow-up, using bivariate and multivariate Cox regression models to calculate prevalence ratios of these outcomes among subjects with different risk factors. Statistical Analysis Software (SAS v9.1)[a] was used for all analyses. This article was reviewed using the Strengthening the Reporting of Observational Studies in Epidemiology checklist to ensure completeness of presentation and contents for observational studies.[26]

Results

At 3 years, follow-up data were available on 888 of 1107 workers (80.2%) (fig 1), with a mean age of 30.3 years (range 18−66y) at baseline; 567 (63.9%) workers were men. No statistically significant baseline differences in symptoms or prevalence of CTS diagnosis were seen at baseline between subjects who were followed and those lost to follow-up. Loss to follow-up was more common among workers with a high school diploma or less education at baseline (n=151, 69.0% of those lost to follow-up vs n=426, 48.0% in the group followed up at 3y; $P<.05$), and among workers who reported lower social support on the 6-month questionnaire (n=35, 29.2% lost to follow-up vs n=147, 18.5% available at follow-up; $P<.05$). No other differences in variables of interest were found between those followed at 3 years and those lost to follow-up.

At baseline, 155 workers (17.5% of the total cohort) (see fig 1) had hand symptoms: 21 met criteria for CTS, 52 had neuropathic symptoms in the median nerve distribution without nerve conduction abnormalities, and 82 had other symptoms in the hand, fingers, or wrist (table 1). The population studied was young and mostly male, less than half had education beyond high school, 16% reported a low social support, and 24% reported workplace exposure to repeated forearm motion over 4h/d on the 6-month questionnaire.

Workers with hand symptoms at baseline were more likely to show limitations and continued hand pain at a later time point: 51 (32.1%) workers who were symptomatic at baseline reported "severe hand pain" at follow-up compared with 111 (15.9%) workers without hand pain at baseline (prevalence ratio 2.17 [95% confidence interval (CI) 1.64−2.88]). Workers with hand symptoms at baseline were also more likely to report job limitations at follow-up than those without hand symptoms (n=34, 21.9% vs n=72, 9.8%, prevalence ratio 2.23 [95% CI 1.54−3.23]). The prevalence of functional status limitations at follow-up was not significantly different between those with hand symptoms at baseline versus those with no symptoms (n=18, 11.6% vs n=59, 8.1%, prevalence ratio 1.44 [95% CI 0.88−2.38]).

At follow-up, 18 of the 155 workers with hand symptoms at baseline demonstrated functional status limitations by Levine's score (11.6%) and 34 reported job limitations (21.9%) (table 2). In the 3-year period, 29 reported limited ability to work, 6 reported decreased productivity, 2 reported lost time from work, 2 reported having been placed on job restrictions due to hand symptoms, and 1 changed employers because of symptoms. Severe hand pain at baseline was closely associated with both functional status and job limitations at follow-up: 83.3% of the 18 subjects who reported functional limitations on the Levine scale reported severe hand pain versus 26.3% who did not report functional limitations (prevalence ratio 3.17 [95% CI 2.24−4.49]); 64.7% of the 34 subjects who reported job limitation reported severe hand pain versus 24.0% who reported no job limitation (prevalence ratio 2.70 [95% CI 1.80−4.04]).

Only 32 of 155 symptomatic subjects (20.7%) reported seeing a physician in the 3-year period. Among the 21 subjects with CTS, 4 (19.1%) reported seeing a physician in that period. Self-reported treatment was low, with 2 subjects receiving hand surgery and 5 receiving steroid injections. Treatment was not included in the statistical models because of the small number receiving treatment. Among the 2 subjects who received CTS surgery, 1 had severe pain and functional limitation at 3-year follow-up; among the 5 subjects who received steroid injection, only 1 had no pain or functional limitation.

Meeting a case definition of electrodiagnostically confirmed CTS at baseline was the greatest predictor of future hand pain

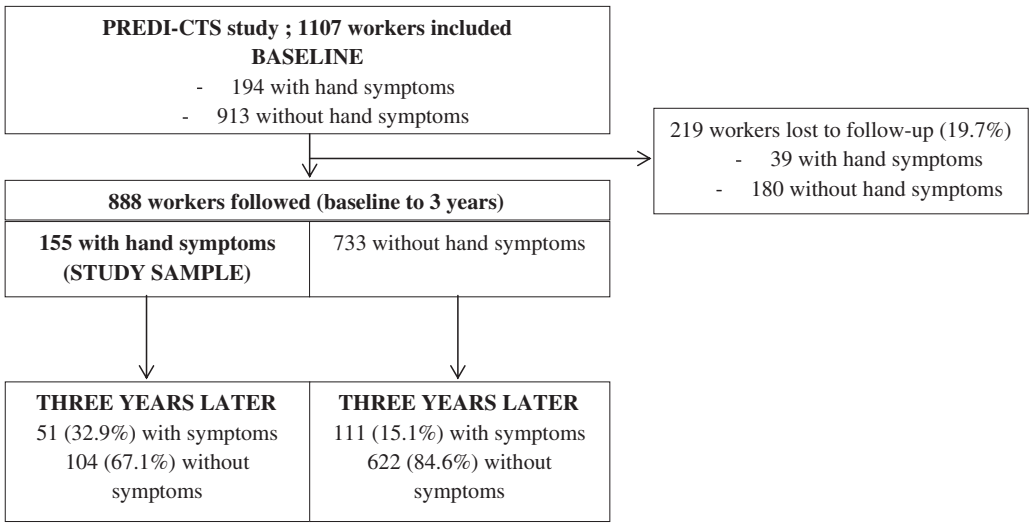

Fig 1 Flow diagram.

Table 1 Description of the selected factors among workers with and without hand symptoms

Variable	Workers Without Hand Symptoms	Workers With Hand Symptoms
Age at baseline (y)	30.43±10.62	29.51±9.16
Sex		
Male	451 (61.5)	116 (74.8)
Female	282 (38.5)	39 (25.2)
Baseline categories of hand pain		
Confirmed CTS	0	21 (13.6)
Symptoms of CTS, NCS−	0	52 (33.6)
Other hand symptoms	0	82 (52.9)
Education level at baseline		
Greater than high school	391 (53.3)	71 (45.8)
High school or less	342 (46.7)	84 (54.2)
Lack of social support*†		
No	527 (71.9)	121 (84.0)
Yes	124 (16.9)	23 (16.0)
Repetitive forearm motion 4 or more hours/d*		
No	581 (79.3)	118 (76.1)
Yes	152 (20.7)	37 (23.9)
Severe hand pain at baseline		
No	733 (100)	84 (54.2)
Yes	0 (0)	71 (45.8)
Total	733	155

NOTE. Values are n (%) or mean ± SD.
Abbreviation: NCS−, negative for nerve conduction study.
* Reported at 6mo in new job.
† Missing data for 11 subjects.

among these workers (table 3): adjusted prevalence ratio was 2.0 for having a severe hand pain versus no pain. Meeting a case definition of electrodiagnostically confirmed CTS at baseline was also associated with functional status limitation on the Levine scale (table 4), with an adjusted prevalence ratio of 3.4 for having a limitation. Female sex also predicted functional status limitation. Low educational level was the only variable associated with our measurement of job limitation.

Discussion

In our study, the natural history of hand symptoms among industrial workers showed the persistence of hand symptoms, with a high prevalence of continued hand pain after 3 years of follow-up. Only a small proportion of symptomatic workers sought medical care or received treatment. Meeting a case definition of electrodiagnostically confirmed CTS at baseline was associated with hand pain and functional limitation among these industrial workers at 3 years, though it did not predict our measure of job limitation.

The persistence of hand pain was high among persons meeting our case definition for CTS, even though effective treatments for CTS are available.[9] In working populations where risk factors are common, this result has also been described by others: Silverstein et al[14] reported the persistence of hand pain in almost half of their worker population at 1-year follow-up. The proportion of the persistence of symptoms was higher in the study by Silverstein[14] compared with the current study, but their workers were older (40.6y vs 29.5y), probably with overall higher physical exposures, and had a higher proportion of CTS at baseline (10.8% vs 2.4%, with similar criteria). Nathan et al[27] found a persistence of hand symptoms, with a 5-year follow-up of a working population, between 22% for pain and 56% for numbness. Spies-Dorgelo et al[28] reported similar persistent hand pain: more than half of their patients

Table 2 Distribution of hand disorders at baseline, and outcomes of pain and limitation at follow-up among the 155 workers with hand pain

Pain and Functional Limitations	Other Hand Symptoms	Symptoms of CTS, NCS−	Confirmed CTS
Baseline pain (n=155 of 888; 17.5%)	82 (9.2)	52 (5.9)	21 (2.4)
Symptom outcome at 36mo			
No hand pain (n=75; 48.4%)	45 (54.9)	25 (48.1)	5 (23.8)
Moderate pain (n=29; 18.7%)	15 (18.3)	11 (21.1)	3 (14.3)
Severe hand pain (n=51; 32.9%)	22 (26.8)	16 (30.8)	13 (61.9)
Functional status limitation on Levine scale (n=18; 11.6%)	6 (7.3)	7 (13.5)	5 (23.8)
Job limitation (n=34; 21.9%)	19 (23.0)	9 (17.3)	6 (28.6)

NOTE. Values are n (%).
Abbreviation: NCS−, negative for nerve conduction study.

Table 3 Prognostic factors associated with pain at 3-y follow-up among workers with hand pain at baseline

	Moderate Hand Pain vs No Pain			Severe Hand Pain vs No Pain		
Prognostic Factors	n (%)*	PR (crude)	PR (adjusted†)	n (%)*	PR (crude)	PR (adjusted†)
Age (y), mean ± SD	29.1 (7.97)	1.00 (0.97–1.04)	1.00 (0.97–1.04)	30.8 (10.57)	1.01 (0.99–1.03)	1.01 (0.99–1.03)
Sex						
Male	24 (20.7)	1	1	36 (31.0)	1	1
Female	5 (12.8)	0.70 (0.30–1.62)	0.77 (0.31–1.90)	15 (38.5)	1.13 (0.71–1.78)	1.07 (0.69–1.66)
Baseline categories of hand pain						
Other hand symptoms	15 (18.3)	1	1	22 (26.8)	1	1
Symptoms of CTS, NCS−	11 (21.2)	1.15 (0.61–2.17)	1.58 (0.82–3.01)	16 (30.8)	0.95 (0.60–1.50)	1.00 (0.57–1.76)
Confirmed CTS	3 (14.3)	1.39 (0.53–3.59)	1.94 (0.72–5.21)	13 (61.9)	2.05 (1.40–3.01)‡	1.98 (1.16–3.38)‡
Education level						
Greater than high school	14 (48.3)	1	1	16 (31.4)	1	1
High school or less	15 (51.7)	1.20 (0.65–2.23)	1.30 (0.64–2.62)	35 (68.6)	1.81 (1.12–2.91)‡	1.54 (0.94–2.52)
Lack of social support						
No	26 (21.5)	1	1	35 (28.9)	1	1
Yes	1 (4.4)	0.30 (0.05–2.00)	0.29 (0.04–2.07)	12 (52.2)	1.48 (0.93–2.35)	1.40 (0.89–2.19)
Repetitive forearm motion						
No	25 (21.2)	1	1	33 (28.0)	1	1
Yes	4 (10.8)	0.72 (0.28–1.82)	0.66 (0.24–1.81)	18 (48.7)	1.54 (1.02–2.33)‡	1.08 (0.66–1.77)
Severe hand pain at baseline						
No	18 (21.4)	1	1	23 (27.4)	1	1
Yes	11 (15.5)	0.87 (0.46–1.65)	0.73 (0.38–1.41)	28 (39.4)	1.34 (0.87–2.05)	1.22 (0.79–1.88)
Total	29 (18.7)			51 (32.90)		

Abbreviations: NCS−, negative for nerve conduction study; PR, prevalence ratio with (95% CI).

* Proportion of cases out of total with hand symptoms at baseline (N).

† Adjustment was made by including all the variables listed.

‡ Indicates variables with significant value.

with CTS coming from general practitioners reported residual symptoms. Our study showed that workers meeting an epidemiologic case definition of CTS (with positive nerve conduction study) were at a higher risk of future hand pain and limitations in functional status than workers with hand pain not meeting our CTS definition.

In addition to meeting the CTS case definition, other factors were associated with pain and functional outcomes, including sex for functional status limitation and low educational level for job limitation. Work exposure factors were less strongly associated with outcomes than expected and significant only in bivariate analyses and in some models on pain outcomes.[14,29,30] Our exposure data were limited to self-reported exposure at one point in time, and by a relatively small number of subjects.

Study limitations

Our study had a number of limitations that may have affected the results. The study population was predominately young men workers who rarely sought medical care. The relatively small overall number of CTS cases is typical of an active working population. Thus, the presented results cannot be directly applied to other populations such as retired workers or patients seeking care for hand symptoms. Another limitation concerns the use of self-reported variables. For the work physical exposure, we used only 1 variable, which has been previously validated[2,31] and previously used in the PrediCTS study.[24] However, this study does not account for potential variation in exposure during the study period, or for the effects of other physical exposures. Self-reported physician visits and treatment may also be subject to inaccuracies, though invasive treatments such as surgery or wrist injections are likely to be recalled. We could not include treatment status in our statistical models because of the small number of subjects reporting treatment.

Other diagnoses of hand pain, such as tendonitis or osteoarthritis, were not specifically studied. We focused on CTS because of its frequency and importance in working populations and because we had a strong case definition based both on symptoms and on electrophysiological measurements on each worker.[29,32] Models were built using variables that covered major known prognostic factors in clinical and occupational studies, although the factors were limited to the data available and did not include a measure for depression or the duration of hand pain.[14,28,33-35] However, considering the objective definition used for carpal tunnel criteria diagnosis,[19,20] the probability of those variables affecting the case definition is low.

The main outcome was based on severe pain with a threshold of 5 or more on a 10-point scale. This outcome seemed valuable because pain is a major symptom in medical practice,[36] and severe pain is usually associated with function and other outcomes.[37] Our results showed a strong prospective relation between pain and functional variables. Our job limitation composite outcome was not as closely associated with CTS as the Levine functional status scale. This variable was composed of several outcomes, including changes in work productivity, change in job, and job limitations; these outcomes are complex and likely affected by many factors other than hand function.

Table 4 Prognostic factors associated with functional impairment between baseline and 3-y follow-up among workers with hand pain at baseline

	Functional Status Impairment on Levine Scale			Job Impairment Using Job Scale		
Prognostic Factors	n (%)	PR (crude)	PR (adjusted*)	n (%)	PR (crude)	PR (adjusted*)
Age (y), mean ± SD	34.61±10.91	1.05 (1.01–1.09)†	1.04 (0.998–1.08)	29.26±10.39	1.00 (0.96–1.03)	1.04 (0.99–1.08)
Sex						
Male	9 (7.8)	1	1	26 (22.4)	1	1
Female	9 (23.1)	2.97 (1.27–6.96)†	2.51 (1.07–5.92)†	8 (20.5)	0.92 (0.45–1.85)	0.96 (0.45–2.03)
Baseline categories of hand pain						
Other hand symptoms	6 (7.3)	1	1	19 (23.2)	1	1
Symptoms of CTS, NCS−	7 (13.5)	1.26 (0.52–3.06)	2.21 (0.69–7.09)	9 (17.3)	0.71 (0.36–1.42)	0.71 (0.32–1.58)
Confirmed CTS	5 (23.8)	2.45 (0.98–6.18)	3.37 (1.01–11.29)†	6 (28.6)	1.37(0.65–2.90)	1.11 (0.45–2.79)
Education level						
Greater than high school	5 (27.8)	1	1	8 (23.5)	1	1
High school or less	13 (72.2)	2.20 (0.82–5.87)	2.09 (0.77–5.70)	26 (76.5)	2.75 (1.33–5.68)†	2.70 (1.25–5.87)†
Lack of social support						
No	10 (8.3)	1	1	27 (22.3)	1	1
Yes	4 (17.4)	2.10 (0.72–6.14)	2.07 (0.64–6.71)	5 (21.8)	0.97 (0.42–2.27)	0.85 (0.39–1.89)
Repetitive forearm motion						
No	11 (9.3)	1	1	23 (19.5)	1	1
Yes	7 (18.9)	2.03 (0.85–4.86)	0.89 (0.30–2.58)	11 (29.7)	1.53 (0.83–2.83)	1.11 (0.52–2.37)
Severe hand pain at baseline						
No	10 (11.9)	1	1	18 (21.4)	1	1
Yes	8 (11.3)	0.95 (0.40–2.27)	0.38 (0.13–1.08)	16 (22.5)	1.05 (0.58–1.91)	0.89 (0.45–1.75)

Abbreviations: NCS−, negative for nerve conduction study; PR, prevalence ratio with (95% CI).
* Adjustment was made by including all the variables listed.
† Indicates variables with significant value.

Conclusions

Our study found that a CTS case definition including symptoms and nerve conduction abnormalities predicted persistent hand pain and future functional status limitations in a large working population. Relatively few workers with pain sought or obtained medical evaluation for their hand symptoms during the 3-year study period. While the natural history of clinically confirmed CTS has been previously described, the prognosis of symptomatic workers without confirmed CTS deserves further study, as these workers seem to be at an increased risk of future pain and functional limitation. Future efforts to prevent functional limitation due to hand symptoms should also take into account the relatively high prevalence of symptomatic workers who do not receive medical evaluation and treatment. Surveillance must also include asymptomatic workers, as many cases in our study arose among this group.

Supplier

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Keywords

Carpal tunnel syndrome; Hand; Pain; Rehabilitation; Task performance; Work

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