Work Increases the Incidence of Carpal Tunnel Syndrome in the General Population

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List of acronyms or abbreviations: AFE, attributable fraction of risk among the exposed persons; BMI, body mass index; $CI_{95\%}$, 95% confidence interval; CTS, carpal tunnel syndrome; EDX, electrodiagnostic; INSEE, French National Institute of Statistics and Economic Studies; RR, relative risk

ABSTRACT: An epidemiological network was set up in a French region to estimate the incidence of CTS in the general population according to employment status. Cases of CTS occurring in patients aged 20 to 59 living in the Maine & Loire region were included prospectively from 2002 to 2004. Medical and occupation history was gathered by mailed questionnaire. Incidence rates of CTS and relative risks (RR) of CTS were computed in relation to employment status. The attributable fractions of risk of CTS to work among the exposed persons (AFE) were calculated. A total of 1,168 patients (819 women, 349 men) were included during the three-year period. The mean incidence rate of CTS per 1,000 person-years was higher in employed compared to unemployed persons (1.7 vs. 0.8 in women and 0.6 vs. 0.3 in men). The excess risk of CTS was statistically significant for male (RR = 4.2) and female (RR = 3.0) blue-collar workers and female lower grade white-collar workers (RR = 2.5). The AFE to work in general was 47% (95% CI, 39-54) in women. AFEs reached higher values in female blue-collar workers (67% [65-68]) and lower grade services, sales and clerical white-collar workers (61% [57-64]). The AFE in male blue-collar workers was 76% [72-80]. In conclusion, the study shows a higher incidence of CTS in the working population compared to the non-working population.

Carpal tunnel syndrome (CTS) is a common clinical problem that frequently requires surgery.[2] Population studies have reported annual incidence rates between 0.5 and 5.1 per 1,000 for CTS defined by electrophysiological criteria[3,8] and between 0.4 and 1.5 per 1,000 for surgical release of the median nerve.[14,15] Although not caused only by work, CTS represents a major proportion of all registered or compensatable work-related diseases in many countries.[4,9] Since many of the individual risk factors of CTS are less modifiable than workplace factors, information about the incidence of CTS in the working population is essential to target prevention efforts. Nevertheless, despite its value from a public health view point, little information is available on the risk of CTS attributable to work factors in the general population.[7,11,14] The French Institute for Public Health Surveillance therefore implemented an epidemiological surveillance system for CTS in the general population of the Maine and Loire (M&L) region in West-Central France in 2002.

The aim of the present study was to assess the incidence of CTS according to employment status and the proportion of cases attributable to work in the general population of the region.

Methods

Protocol

Population: The population included in this study comprised residents of the M&L region between the ages of 20-59 [194,276 women (50.1%) and 193,802 men (49.9%)].

Outcome definition: Subjects who had undergone electrodiagnostic (EDX) studies of the upper limbs by the five sentinel physicians of the only four electrodiagnostic centers of the M&L region were eligible for the study if they were residents of the defined geographic area. Only cases of CTS without prior history of CTS of the same wrist were included prospectively between 2002 and 2004. Incident cases of CTS were defined by both clinical and electrophysiological criteria using the same standardized protocol, which followed the published recommendations.[5] To be included, symptoms had to be classified as classic/probable CTS according to the consensus criteria for CTS classification in epidemiological studies,[12] and at least two of the following EDX criteria were required: (1) delay in the distal motor latency of the median nerve (DML) (upper limit of normal, 3.6 ms); (2) decrease in sensory conduction velocity of the median nerve assessed orthodromically between the thumb, third digit and wrist (lower limit of normal, 40 m/s); (3) relative delay in sensory distal latency of the median nerve compared with the ulnar nerve at the 4th digit (upper limit of normal, 0.5 ms); (4) decrease in amplitude of the median sensory nerve action potentials (SNAP) at the thumb and third digit (lower limit of normal, 10 μV); and (5) abnormalities of the recruitment pattern of the abductor pollici brevis muscle during needle electromyography.

Inclusion and data collection procedure: Each eligible patient was informed of the study by the physician and signed a consent form after the clinical and neurophysiologic examinations. Medical history, including prior history of CTS, hand symptoms, and the conclusion on the EDX study of the median nerve(s) were reported to our laboratory. Although the EDX study was similar for all subjects, detailed EDX data were available for only 1,024 subjects (90%) (corresponding to 763 and 573 cases of CTS affecting the right and left wrist, respectively). For the other (10% of cases), only the conclusion of the EDX study was available. A self-administered questionnaire was then mailed to each subject. Information was collected on medical and surgical history (obesity, diabetes mellitus, thyroid disease, gynecological history, wrist/hand trauma, prior CTS, and upper limb musculoskeletal disorders) and employment (industry, occupation, and description of tasks during the preceding 5 years). The response rate to the questionnaire was 97%.

Quality control of the data was performed for 100 subjects randomly selected in 2002 and interviewed by telephone 6 months later. To assess the possibility of inclusion bias, all patients included in the study in 2002 were compared with patients having undergone surgical release of the median nerve in 2002-2003 using the medical files of the Angers Hand Center, which performed about 70% of interventions for surgical release of the median nerve in the M&L region.

Analysis

The characteristics of the general population of the M&L region were extracted from the French National Institute of Statistics and Economic Studies (INSEE) census of 1999. Incidence rates were estimated by patient and not by wrist, so that each patient with bilateral CTS was regarded as one case. The date of the EDX study was used to define the date of diagnosis of CTS, because the date of the onset of symptoms was imprecise or not available for about 30% of cases.

Age- and gender-specific annual incidence rates were computed with the number of persons suffering from CTS newly diagnosed during the year under consideration as numerator. Assuming that the general population remained stable, the denominator was an estimate of the average number of person-years of the same age and gender during the same period based on the 1999 INSEE census data.[6] The age-adjusted relative risks (RR) of CTS in working subjects during the year of diagnosis, compared to non-working subjects during the year of diagnosis, were computed according to work in general and to work in specific industry and occupation categories using the Mantel-Haenszel method for each gender. The attributable fraction of risk in exposed individuals (AFE [%]) was computed to estimate the proportion of cases of CTS attributable to work using the following formula:[1]

$$AFE = (RR-1)/RR \qquad \text{(equation 1)}$$

Statistical analyses were performed using SPSS 13.0 software.

Results

A total of 1,168 cases (819 women, 349 men; male:female ratio 1:2.5), corresponding to 1,644 wrists affected by CTS, were included during the 3-year period. Few eligible patients refused to sign the consent form, mainly because of lack of time. There was no recording of the refusals, but the estimate given by the sentinel physicians was less than 10%.

CTS affected the right, left, or both wrists in 40%, 22%, and 38% of cases, respectively. For both genders, symptoms were classic CTS in about 80% of cases for both wrists. The main EDX criteria used to defined CTS were a delay in the DML of the median nerve, a decrease in the sensory conduction velocity, and more rarely a decrease in the SNAP amplitude. An increase of the median / ulnar latency difference was less frequent because this measure was performed only in case of mild CTS (Table 1).

The quality control of the data for 100 randomly selected subjects showed no information bias between the self-administered questionnaire and the interview regarding gender, age, or employment status. Comparison of 391 cases included in 2002 with the 2002 and 2003 medical files of the Angers Hand Center showed that about 60% of the cases of CTS undergoing surgery were not identified by our network. No difference was found between these sources regarding age, gender, employment status, or last occupation. The proportions of subjects working in the manufacturing, agriculture, construction, and service industries did not differ between these two sources. The proportion of blue-collar workers and lower grade white-collar workers was in the same order of magnitude for both sources.

Medical and surgical history and employment status were only available for the 815 women and 320 men who completed the questionnaire. Men [mean age 43.3 (SD 9.5) yrs] and women [mean age 44.9 (SD 9.3) yrs] suffering from CTS were relatively young (Table 2). Few incident cases of CTS were diagnosed during pregnancy (2%) and about 33% of women aged between 20-49 years had used oral contraceptives. The prevalence of obesity (BMI >30 kg/m²) was similar between men and women (16%). The prevalence of diabetes mellitus was 4%, without difference between genders. The prevalence of thyroid disease was high only in women (13%). Further, 20% of men and 30% of women had obesity, diabetes mellitus, and/or thyroid disease, the age-adjusted prevalence increasing significantly in case of unemployment (38% vs. 25%; P < 0.001). The prevalence of these disorders did not vary significantly according to industry or occupation categories.

The crude average 12-month incidence of CTS over the 3-year period was 1.4 for 1,000 person-years in women and 0.6 for 1,000 person-years in men. The incidence of CTS in 2002, 2003, and 2004 was 1.5, 1.6, and 1.2 and 0.6, 0.7, and 0.6 for 1,000 person-years in women and men, respectively. The decrease of incidence observed for women in 2004 was not statistically significant and both the male:female ratio and the proportion of working subjects did not vary significantly during the period. Incidence increased with age (P < 0.001) in both genders, whatever the employment status (Table 2). The proportion of working subjects was higher in patients with CTS than in the general population of the M&L region (90% vs. 81% in men and 80% vs. 66% in women). The crude mean incidence rate of CTS per 1,000 person-years was higher in employed persons than among those unemployed in the year of diagnosis [1.69 vs. 0.84 in women and 0.61 vs. 0.30 in men (both P < 0.001)]. The latter category comprised both subjects who had never worked, mainly women, and unemployed subjects in the year of diagnosis. The age-adjusted RR in employed subjects compared with those unemployed in the year of diagnosis was 1.9 [95% CI, 1.6-2.3] in women and 1.3 [95% CI, 0.9-1.9] in men.

The employed subjects suffering from CTS were mainly lower grade white-collar workers and blue-collar workers and rarely belonged to more qualified occupation categories. The excess of risk of CTS was statistically significant for male and female blue-collar workers and female lower grade services, sales, and clerical white-collar workers (Table 3). In contrast, higher level occupation categories, such as women crafts- and salespersons and managers, technicians, and associate professionals of both genders, were associated with a lower risk of CTS. In terms of industry, working in agriculture (for women), manufacturing (for both genders), construction (for men) and, to a lesser extent, service industries (for women) was associated with an excess risk of CTS. In contrast, working in the service industries was associated with a lower risk of CTS for men (Table 4). Among women, this latter sector mainly involved blue-collar and lower grade white-collar workers (84%); among men, it involved blue-collar workers (49%) and also a relatively large percentage (29%) of qualified white-collar workers and professionals.

The attributable fraction (AFE) in employed persons, which represents the proportion of CTS specifically attributable to work among cases occurring in the working population was 47% (95% CI, 39-54) for women and could not be computed for men. The AFE of CTS reached values over 60% for female and male blue-collar workers and female lower grade services, sales, and clerical white-collar workers (Table 3). In terms of industry, the AFE of CTS was higher in agriculture (for women) and construction industry (for men) than in manufacturing (for both genders) and the service industries (for women) (Table 4).

Discussion

The strength of this study lies in the inclusion of incident CTS in the general population reported by a sentinel surveillance network of physicians covering a large area of the region. Case definition agreed with the consensus definitions for epidemiological surveillance of CTS[9,12] and took into account the published recommendations[5] for neurophysiologic studies of CTS. One limitation of the study was the lack of exhaustiveness of the sentinel network which led to an underestimation of the incidence of CTS. The lack of exhaustiveness of the network could be explained by different factors. The number of persons suffering from CTS without undergoing EDX studies is unknown but probably high. It might be possible that employed subjects would be more likely to undergo EDX studies or surgical release than unemployed subjects. Nevertheless, this source of bias is probably low in France, since most of the costs are paid by the Social Security, whatever the employment status of the patients. In some patients, surgical release of the median nerve was performed without EDX studies during the preceding 36 months. However, they might have an electrodiagnostic evaluation earlier. For that reason, surgical data and EDX studies are not easy to compare at the individual level. Some people living in the M&L area might have undergone electrodiagnostic studies in an area not covered by the network (probably less than 5% of eligible cases). A few eligible cases refused to sign the consent form for several reasons, mainly for lack of time. The lack of exhaustiveness was also due to the unequal participation of the sentinel physicians over the three-year period, mainly in 2004. One physician notified very few cases over the three years and another left the network in 2003 for personal reason. In addition, some eligible cases were not included because of time pressure. Such reasons were also reported in a similar sentinel network in the USA.[4] The lack of exhaustiveness of the network explains the relatively low estimate of incidence of CTS in this general population compared to those recently reported in the general populations of Canterbury and Sienna using electrophysiological definition of CTS.[3,8] However, no significant differences were observed between patients included in the study and those treated surgically regarding age, gender and last occupation. Consequently, even though the incidence of CTS was underestimated, estimates of relative risk of CTS according to gender, age and employment status would be expected to be unbiased.

The methodology we used did not allow precise assessment of biomechanical and psychosocial risk factors for CTS. Consequently, the industry (or the occupation category) was used as a «proxy» for exposure to risk factors for CTS.[11] Due to the small number of unemployed patients, the precision of the estimates of the age-adjusted RR and AFE of CTS in employed subjects was relatively low.

As previously reported in population-based studies, the incidence of CTS was higher in women and increased with age for both genders.[3,8] Fewer than 2% of women included in the study were pregnant and the proportion of women using oral contraception was similar to that observed in the general population.[13] The prevalence of diabetes mellitus in patients was twice as high that in the general population of the same age,[13] and this confirms the findings of surgical series.[15] Considering that no reference data standardized for sex and age were available for the general population of the Maine & Loire region concerning diabetes mellitus, we could not compute the relative risk of CTS according to diabetes. Obesity was twice as frequent as in the general population of the region aged 15 years or more and this agrees with surveys in the general population.[2] Unfortunately, the available data on obesity in the general population of this area do not allow more precise analysis of the relative role of obesity and occupation on the risk of CTS. Although the study confirmed the co-existence of medical conditions known to increase the risk of CTS in some patients, it also showed that about 70% of female and 80% of male patients did not suffer from any of them. Thus, most cases occurred in relatively young and healthy working women and men. This epidemiological profile of CTS in this general population differs drastically from the historical clinical profile of CTS, according to which CTS occurs mainly in middle-aged women suffering from hormonal disorders.[9,15] A substantial number of cases occurred in subjects less than 30 years of age, raising concerns about the potential long term effects of CTS not only on musculoskeletal health but also on employment.[4]

This study shows that most cases of CTS in the general population occurred in working subjects of both genders, particularly in blue-collar workers and lower grade white-collar workers. Estimates of the RR of CTS were between 1.5 and 2 in working subjects in general and 3 to 4 in blue-collar workers. These results are consistent with epidemiologic studies showing higher incidence rates of CTS in certain occupational groups, mainly industrial workers.[4,9,10] All the main industries were involved, except for service industries for men, with RR ranging from 1.8 to 3.0. However, RR might have been underestimated because of the "dilution" of very exposed specific activities such as food processing and cleaning, among less highly exposed occupations.[4,14] The results support the opinion that occupational risk factors for CTS are concentrated in workers most exposed to repetitive movements and/or heavy physical workload. The risk of CTS associated with work in the service sector drastically differed between genders. This probably reflect the gender division of work in this sector, since most of the women belonged to two high risk low qualified occupation categories, whereas many men belonged to high grade occupations with a low risk of CTS.

Despite its value from the public health view point, little information is available to assess the AFE of CTS to work,[7] representing the mean proportion of CTS attributable to work among working subjects. In our study, about 47% of cases of CTS in working women could be attributed to work. The statistical power was insufficient to provide a clear conclusion regarding this fraction in working men. However, it should be borne in mind that the calculation of AFE involved work in general, and estimates of AFE were higher in occupation groups with greater exposure to semi-routine or routine manual work. Thus, CTS cases could be considered as attributable to work for about three-quarters of male blue-collar workers, two-thirds of female blue-collar workers and more than half of female lower grade services, sales and clerical white-collar workers. Estimate of AFE in working women in our study was close to that calculated in the Montreal study (55%) comparing the incidence of surgical release of the median nerve between manual and non-manual workers in 1994-5.[14] Our estimates were also close to those of their study when we only considered blue-collar workers of both genders. The latter results suggest that work-related factors increase the risk of CTS, but more refined methodology should provide more precise assessment of the factors involved. AFE did not take into account any individual characteristics of work and non-work exposure or medical history and thus did not determine the causal relationship between CTS and work at the individual level.[1]

Conclusion

Epidemiological surveillance of CTS in a general population in this study showed a higher incidence of CTS in the working population compared to the non-working population. A substantial proportion of cases of CTS diagnosed in the lower grade white-collar worker and blue-collar worker categories were attributable to work. Although the results must be confirmed in other areas, they provide important new insights to measure the impact of an excess risk of CTS in the working population and to target preventive action.

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Table 1. Description of the incident cases of CTS: Electrodiagnostic findings

Electrodiagnostic criteria*	Positive EDX findings (%)
Distal motor latency of the median nerve ≥ 3.6 ms (1)	74
Sensory conduction velocity of the median nerve < 40 m/s (2)	83
Median / ulnar distal latency difference ≥ 0.5 ms (3)	18
Median SNAP < 10 µV (4)	45
Abnormalities of the recruitment pattern of the abductor pollici brevis muscle (5)	49
(1) and (2)	71
(1) and (4)	42
(2) and (4)	43

* Data available for 1,024 subjects corresponding to 763 and 573 cases of CTS affecting the right and left wrists, respectively. Data are expressed as the percentage of incident cases. See the text for details on the EDX criteria.

Table 2. Incidence of CTS according to age, gender and employment status§

	WOMEN				MEN			
	EMPLOYED		UNEMPLOYED		EMPLOYED		UNEMPLOYED	
Age (yrs)	(n)	Incidence	(n)	Incidence	(n)	Incidence	(n)	Incidence
20-29	(38)	0.46	(20)	0.37	(24)	0.24	(7)	0.16
30-39	(147)	1.31	(32)	1.39	(75)	0.54	(7)	0.50
40-49	(231)	1.93	(35)	0.47	(102)	0.73	(2)	0.07
50-59	(232)	3.28	(80)	1.73	(84)	0.94	(19)	0.74
Total	(648)	1.69	(167)	0.84	(285)	0.61	(35)	0.30

§ 815 females and 320 males having completed the questionnaire are included; * Data represent number (n) and mean incidence rate of CTS per 1,000 person-years.

Table 3. Relative risks and attributable risk fractions of CTS according to occupation category in exposed persons

OCCUPATION CATEGORY*	Pe (%)	N (%)	RR [$CI_{95\%}$]	AFE (%)[$CI_{95\%}$]
WOMEN				
1. Farmers	1.9	18 (2.2)	1.2 [0.8-2.0]	-
2. Craftswomen, saleswomen and managers	2.3	10 (1.2)	0.5 [0.3-1.2]	-
3. Professionals	4.3	23 (2.8)	0.9 [0.6-1.4]	-
4. Technicians, associate professionals	14.2	57 (7.0)	0.6 [0.5-0.8]	-
5. Lower grade white-collar workers	30.5	346 (42.5)	2.5 [2.2-3.0]	60.5 [57.1 - 63.6]
6. Blue-collar workers	12.4	194 (23.8)	3.0 [2.5-3.6]	66.6 [64.9 - 68.3]
7. Non-working persons§	34.4	167 (20.5)	1	-
MEN				
1. Farmers	4.8	14 (4.4)	1.3 [0.8-2.3]	-
2. Craftsmen, Salesmen, managers	6.3	14 (4.4)	0.8 [0.4-1.6]	-
3. Professionals	9.1	17 (5.3)	0.6 [0.4-1.0]	-
4. Technicians, associate professionals	16.7	27 (8.4)	0.6 [0.4-0.8]	-
5. Lower grade white-collar workers	7.8	18 (5.6)	1.3 [0.8-2.1]	-
6. Blue-collar workers	35.9	195 (60.9)	4.2 [3.3-5.5]	76.4 [71.9 - 80.2]
7. Non-working persons§	19.3	35 (10.9)	1	-

* Persons working during the year of the diagnosis; Pe (%): percentage of the occupation in the general population of the Maine-et-Loire area; N (%): number and percentage of CTS incident cases; $CI_{95\%}$: 95% confidence interval; § Reference group

Table 4. Relative risks and attributable risk fractions of CTS according to industry in exposed persons

INDUSTRY (NACE code)*	Pe (%)	N (%)	RR [$CI_{95\%}$]	AFE (%)[$CI_{95\%}$]
WOMEN				
1. Agriculture	4.0	71 (8.7)	2.5 [2.0-3.20]	60.2 [59.2-61.2]
2. Construction	0.7	4 (0.5)	4.7 [1.0-13.0]	-
3. Manufacturing	11.5	141 (17.3)	2.1 [1.7-2.5]	52.1 [50.1-54.0]
4. Service industries	49.5	424 (52.0)	1.7 [1.5-2.1]	43.5 [37.2-49.1]
6. Non-working persons§ α	34.4	167 (20.5)	1	-
MEN				
1. Agriculture	8.7	31 (10.0)	1.4 [0.9-2.0]	-
2. Construction	8.2	58 (18.1)	3.0 [2.2-4.0]	66.5 [64.4-68.4]
3. Manufacturing	22.0	104 (32.5)	2.0 [1.5-2.5]	49.2 [44.5 - 53.4]
4. Service industries	41.8	88 (27.5)	0.6 [0.6-0.8]	-
6. Non-working persons§ α	19.3	35 (10.9)	1	-

* Persons working during the year of the diagnosis; Pe (%): percentage of the industry in the general population of the Maine-et-Loire area; N (%): number and percentage of CTS incident cases; $CI_{95\%}$: 95% confidence interval; § Reference group ; α : Unspecified sector: 8 for women (1%) and 4 for men (1.3%).