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Attributable risk of carpal tunnel syndrome in the general population – implications for intervention programs in the workplace

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Objective Carpal tunnel syndrome (CTS) represents one of the most significant and costly health problems occurring in the working population. An estimation of the potential impact of CTS prevention programs in the workplace would be useful for public policy. The aim of this study was to assess the work-related population-attributable fraction (PAF) of CTS in industrial sectors and occupational categories at high risk of CTS in the general population.

Methods All cases of CTS occurring in patients living in a French region were included prospectively between 2002–2004. Using a mailed questionnaire, we gathered medical and occupational history from 815 women and 320 men. We calculated the age-adjusted relative risks and PAF of CTS in relation to industrial sectors and occupational categories.

Results The PAF for women was higher in lower-grade, white-collar workers [24%, 95% confidence interval (95% CI) 19–29] than blue-collar workers (19%, 95% CI 15–22). The PAF was higher for the service industries sector (16%, 95% CI 8–22) than manufacturing (10%, 95% CI 7–13) or agricultural (5%, 95% CI 3–7) sectors. The PAF was high for men in blue-collar workers (50%, 95% CI 41–57) and in the construction (13%, 95% CI 9–18) and manufacturing industries (17%, 95% CI 10–23).

Conclusion The study suggested that 5–50% of CTS cases might be avoided in the whole population if totally effective intervention programs were implemented in specific occupational categories or industrial sectors.

Key terms burden of disease; CTS; population attributable risk; prevention; work; work-related risk factor.

Carpal tunnel syndrome (CTS) represents one of the most significant and costly health problems occurring in the working population worldwide (1). Epidemiological studies have identified several combinations of personal and work-related risk factors for CTS (1–3). Most work-related risk factors for CTS are more modifiable than individual risk factors, and the implementation of intervention programs in the workplace is expected to reduce the burden of CTS in the population (1). Using the results of a large survey of musculoskeletal disorders and their risk factors in the working population of the Pays de la Loire region in France, we recently calculated

that up to 31% of cases in manual workers could theoretically be prevented by lowering the levels of physical work exposure in that population (4). The proportion of avoidable work-related musculoskeletal disorders is less in the whole working population (5).

In France, as in many countries, information regarding CTS and its risk factors at the general population level is still scant, although more information is available at the workplace level (6). The French Institute for Public Health Surveillance, therefore, implemented an epidemiological surveillance system for CTS in the general population of the Maine-et-Loire region in West-Central France

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in 2002 to assess the risk of CTS according to industry and occupation, and the proportion of those cases that might be attributable to work. Recently reported results (7) showed a higher incidence rate of CTS in employed than in unemployed persons, with the highest risks occurring in two occupational categories (lower-grade, white-collar workers for women and blue-collar workers for both genders) and four major industries (agriculture and service industries for women, manufacturing for both genders, and construction for men). Assuming that other risk factors remain unchanged and that there is a causal relationship between work exposure and CTS, the population-attributable fractions (PAF) of CTS for work in high-risk industries and occupations should reveal the proportion of CTS cases that might be prevented following a reduction in the risk of CTS at the workplace level (8). Such information thus provides an estimation of the theoretically maximum potential impact of the CTS prevention programs in the workplace (9). This would be particularly useful for public policy and those selecting which sectors or occupations require intervention. Our aim in this study was, therefore, to assess the work-related PAF of CTS for the main industrial sectors and occupational categories characterized by a high risk of CTS in a general French population.

Methods

Population

The population included in the CTS surveillance program comprised residents of the Maine-et-Loire region in the 20–59 age group (194 276 women and 193 802 men). According to the French National Institute of Statistics and Economic Studies (INSEE) census of 1999, the economic structure of the region was diversified and similar overall to that of most French regions, with the exception of Paris. The main sectors were distributed as follows: agriculture (women, 6%; men, 11%), construction (women, 1%; men, 10%), manufacturing (women, 18%; men, 27%) and service industries (women, 75%; men, 52%). The employment rate was 66% for women and 81% for men.

Outcome definition

Only residents of the Maine-et-Loire region who had undergone electrodiagnostic studies of the upper-limbs conducted by the five physicians working at the four electrodiagnostic centers in the area were eligible for the study. Of these, only cases of CTS – without prior history of CTS of the same wrist – were included prospectively between 2002–2004. All incident cases of CTS were

defined by both clinical and electrophysiological criteria using the same standardized protocol, which followed published recommendations (10, 11). To be included, symptoms had to be classified as classic/probable CTS using the Katz hand diagram (10); at least two of the following electrodiagnostic study criteria were required (11): (i) delay in the distal motor latency of the median nerve, (ii) decrease in sensory conduction velocity of the median nerve, (iii) decrease in amplitude of the sensory potentials, or (iv) a relative delay in sensory distal latency of the median nerve compared with the ulnar nerve. See Roquelaure et al (7) for details.

Inclusion and data collection procedure

The physician informed each eligible patient about the study; a patient consent form was signed after the clinical examination and electrodiagnostic study. Medical history (including prior history of CTS), hand symptoms, and the conclusion of the electrodiagnostic study regarding the median nerve(s) were reported to our laboratory. A self-administered questionnaire was then mailed to each subject. Information was collected on: (i) medical and surgical history including obesity (defined by body mass index >30 kg/m²), diabetes mellitus, thyroid disorders, gynecological history, wrist/hand trauma, prior CTS, and upper limb musculoskeletal disorders, and (ii) employment (industry, occupation, and description of tasks during the preceding five years). See Roquelaure et al (7) for details.

Coding of occupations

Jobs were coded for economic activity of place of employment and occupation, using the one-digit codes of the French version of the Classification of Economic Activities in the European Community (NAF codes, 4 classes) and the French classification of occupations (PCS codes, 8 classes). The lower-grade, white-collar category includes employees in the trade and commerce (eg, cashiers) and personal service industries (eg, hairdressers and waitresses), and lower-grade, government executive officials and public service workers (eg, school cleaners, nurses' aides, and lower-grade public office workers). The blue-collar category includes material handlers, skilled and unskilled industrial workers (eg, machine and food operators), skilled and unskilled craft workers (eg, plumbers and bricklayers), and unskilled agricultural workers (eg, horticulture and vineyard workers).

Analysis

The characteristics of the general population of the Maine-et-Loire region were extracted from the 1999 INSEE census, which was the last available census

at the time of the study. Incidence rates were estimated per patient and not per wrist, so that any patient with bilateral CTS was regarded as a single case. As the date of onset of symptoms was imprecise or not available for about 30% of cases, the date of the electrodiagnostic study was used to define the date of CTS diagnosis.

We computed age- and gender-specific annual incidence rates with the numerator being the number of persons suffering from newly diagnosed CTS during the year under consideration. Assuming that the general population remained stable, the denominator was an estimate of the average number of person-years during the same period based on the 1999 INSEE census data (12). Using the Mantel-Haenszel method, we computed the age-adjusted relative risks (RR) of CTS according to industrial sectors and occupational categories, with the whole sample of subjects included in the study as reference, whether they were employed at the time of diagnosis or not. The non-working subjects included subjects who had never worked (mainly women), pensioners, and all unemployed subjects in the year of diagnosis or the year of the census. Subsequently, the work-related PAF of risk in the occupational category (or industrial sector) under consideration was computed using the following formula (12):

$$\text{PAF} = \text{Pe} (\text{RR}-1) / [\text{Pe} (\text{RR}-1) + 1]. \quad \text{equation 1}$$

The PAF takes into consideration the proportion (Pe) of subjects involved in the general population and represents the proportion of cases of CTS in the whole population for each gender which could be avoided if the occupational category (or industrial sector) under consideration was not exposed to an excess risk of CTS (12).

Results

A total of 1168 cases (819 women, 349 men; male to female ratio of 1 : 2.3), corresponding to 1644 wrists affected by CTS, were included during the three-year period. Medical and surgical history, and employment status were available for the 815 women and 320 men who completed the questionnaire. The mean age was 44.9 years (SD 9.4) for women and 43.3 years (SD 9.5) for men. The population-based annual incidence rates of CTS were 1.4 per 1000 females and 0.6 per 1000 males, and increased substantially with age for both genders ($P < 0.001$). The prevalence of obesity (16%) and diabetes mellitus (4%) were similar in men and women. The prevalence of thyroid disorders was high only in women (13%). Furthermore, 20% of men and 30% of women were obese, or had diabetes mellitus or thyroid disorders, without significant differences in occupation or industry.

About 79% of women and 89% of men suffering from CTS were working at the time of diagnosis; 90% of women and 97% of men had worked in the five-year period before diagnosis. The mean length of employment in the previous job was seven years, with no difference between men and women. Most men (71%) and women (62%) had held the same job during the preceding five years. Few men had occupied two jobs (13%) or more (8%) during this period, the corresponding values for women were 16% and 10%. In most of these cases, the changes in occupation in the period preceding diagnosis did not modify the industrial sector or occupational category.

The excess risk of CTS was statistically significant for two main occupational categories: blue-collar workers (for both genders) and lower-grade services, sales and clerical white-collar workers (for women) (table 1). The excess risk of CTS in female, blue-collar workers occurred mainly in skilled, blue-collar workers [RR 3.2, 95% confidence interval (95% CI) 2.7–3.8] and unskilled, agricultural workers (RR 4.2, 95% CI 3.2–5.7). For male, blue-collar workers, the excess risk of CTS occurred in skilled (RR 1.8, 95% CI 1.5–2.3) and unskilled (RR 3.5, 95% CI 2.7–4.5) blue-collar workers and unskilled, agricultural workers (RR 3.5, 95% CI 2.2–5.5).

In terms of industrial sectors, work in agriculture (for women), manufacturing (for both genders), construction (for men) and service industries (for women) was associated with an excess risk of CTS (table 2). For women, the service sector mainly involved blue-collar and lower-grade, white-collar workers (84%). For men, the service industry comprised blue-collar workers (49%), but also a relatively large percentage (29%) of qualified white-collar workers and professionals (data not shown).

The PAF of CTS for male, blue-collar workers reached 50% (table 1), suggesting that more than half of the CTS cases diagnosed in the population could be avoided if the excess risk of CTS in blue-collar workers could be eliminated. Considering the subcategories of blue-collar workers in men at high risk of CTS, the PAF was 15.7% (95% CI 8.8–22.1) for skilled workers, 20.9% (95% CI 15.3–26.1) for unskilled workers, and 6.9% (95% CI 3.6–10.2) for agricultural workers (data not shown). The PAF was lower for female, blue-collar workers (19%), but reached a higher value (24%) for female, lower-grade services, sales, and clerical white-collar workers. In the two subcategories of female, blue-collar workers at high risk of CTS, the PAF was 13.2% (95% CI 10.2–16.0) for unskilled workers and 5.0% (95% CI 3.6–6.7) for agricultural workers (data not shown).

The PAF for women was higher in the service industries sector (16%), which is the largest industry sector in the region, than manufacturing (10%) or agricultural

Table 1. Relative risks (RR) and population-attributable fractions (PAF) of risk of carpal tunnel syndrome (CTS) according to occupational categories [PCS = French classification of occupations; Pe (%): percentage of the general population of the Maine-et-Loire area; N (%) = number and distribution of CTS incident cases by occupational category; 95% CI = 95% confidence interval]

Occupational category (PSC code) ^{a, b}	Pe (%)	N	%	RR	95% CI	PAF (%)	95% CI ^c
Women							
Farmers	1.9	19	2.3	1.0	0.6–1.5	-	..
Craftswomen, saleswomen and managers	2.3	10	1.2	0.5	0.3–0.9	-	..
Professionals	4.3	23	2.8	0.7	0.5–1.0	-	..
Technicians, associate professionals	14.2	64	7.8	0.6	0.4–0.7	-	..
Lower-grade, white-collar workers	30.5	384	46.8	2.0	1.8–2.3	23.8	18.7–28.5
Blue-collar workers	12.4	234	28.5	2.9	2.5–3.4	18.9	15.3–22.4
Pensioners and other non-working persons	34.4	80	9.8	0.2	0.2–0.3	-	..
Men							
Farmers	4.8	14	4.4	1.2	0.7–2.1	-	..
Craftsmen, salesmen, and managers	6.3	13	4.1	0.6	0.3–1.0	-	..
Professionals	9.1	17	5.3	0.7	0.4–1.2	-	..
Technicians, associate professionals	16.7	29	9.2	0.5	0.4–0.8	-	..
Lower-grade, white-collar workers	7.8	24	7.6	1.3	0.8–2.0	-	..
Blue-collar workers	35.9	210	66.7	3.8	3.0–4.7	49.7	41.3–56.8
Pensioners and other non-working persons	19.4	10	3.1	0.2	0.1–0.4	-	..

^a Persons working during the five-year period before the diagnosis.

^b Unspecified categories: six for women (0.7%) and four for men (1.3%).

^c Range computed using the lower and upper limits of the confidence interval of the RR of CTS in equation 1.

Table 2. Relative risks (RR) and population-attributable fractions (PAF) of risk of carpal tunnel syndrome (CTS) according to industrial sectors. [NAF = French version of the Classification of Economic Activities in the European Community; Pe (%) = percentage of the general population of the Maine-et-Loire area; N (%) = number and distribution of CTS incident cases by industrial sector; 95% CI = 95% confidence interval]

Industrial sector (NAF code) ^{a, b, c}	Pe (%)	N	%	RR	95% CI	PAF (%)	95% CI ^d
Women							
Agriculture	4.0	80	9.8	2.4	1.9–3.0	5.2	3.1–7.2
Construction	0.7	6	0.7	2.3	1.0–5.2	-	..
Manufacturing	11.5	166	20.4	2.0	1.7–2.4	10.3	7.1–13.4
Service industries	49.5	477	58.5	1.4	1.2–1.6	16.0	8.9–22.0
Men							
Agriculture	8.7	34	10.6	1.3	0.9–1.9	-	..
Construction	8.2	63	19.7	2.9	2.2–3.8	13.3	8.4–18.0
Manufacturing	22.0	115	35.9	1.9	1.5–2.4	17.0	10.0–23.5
Service industries	41.8	93	29.1	0.5	0.4–0.7	-	..

^a Persons working during the five-year period before the diagnosis.

^b Unspecified sector: one for women (0.1%) and three for men (1.0%).

^c Non-working persons have no NAF code (80 women and 10 men).

^d Range computed using the lower and upper limits of the confidence interval of the RR of CTS in equation 1.

(5%) sectors. The PAF for men was relatively high for two sectors, namely, construction (13%) and manufacturing (17%) (table 2).

Discussion

A strength of this study was the inclusion of incident cases of CTS in the general population reported by a sentinel surveillance network of physicians covering almost all the inhabitants of the region, irrespective of

their employment status. The organization, efficacy, and representativeness of the CTS surveillance network have been discussed elsewhere (7). Schematically, the extent of the network was not completely exhaustive due to several factors. For example, some people living in the Maine-et-Loire area might have undergone electrodiagnostic studies in an area not covered by the network. A few eligible subjects refused to sign the consent form for various reasons, but mainly due to a lack of time. The participation of the sentinel physicians over the three-year period was uneven since one physician notified us of very few cases and another left the network in 2003

for personal reasons. In addition, some eligible cases were not included by physicians also because of lack of time. However, no significant differences regarding age, gender, and last occupation were observed between the patients included in our study and those treated surgically in the same area (7). This indicates that there was no systematic inclusion bias of CTS cases in the surveillance program reported here according to age, gender, employment status, and last occupation. Consequently, even if the incidence of CTS was underestimated, RR estimates of CTS by industrial sector and occupational category should be considered as unbiased, and the PAF estimate of CTS viewed as accurate. See Roquelaure et al (7) for details.

Work exposure was appraised at the level of industry and job-title without in-plant job analysis, and therefore no precise assessment of the actual exposure to biomechanical and psychosocial risk factors of CTS was performed. Using methodology comparable to that of the INSEE census, the collection and coding of occupational and economic activity information was based on detailed information about the jobs and tasks. Most patients were actively employed during the five years before, and at the time of, the diagnosis. The length of service was high and most workers had remained in the same occupation during this period. Moreover, when occupational changes occurred, we observed very few shifts from one occupational category (or industrial sector) to another. We checked that the results for the CTS cases requiring surgical release of the median nerve were similar using three slightly different definitions of occupation: (i) occupation at the time of surgery, (ii) most recent occupation in the five years before surgery, and (iii) longest occupation in the five-year period. This is consistent with the fact that the most recent occupation was also the longest one for most patients. CTS cases in 2002–2004 were compared to the 1999 census and some changes might have occurred in the population between 1999–2004. Nevertheless, as previously stated, the length of service in the last job was high and most workers did not shift from one occupational category (or industrial sector) to another during this period.

The reference group was enlarged to the whole sample of subjects. Consequently, the age-adjusted RR and the PAF of CTS in specific industries and occupational categories were underestimated because the comparison group included a substantial proportion of industrial and occupational groups at high risk of CTS (13). Since only limited information on medical history was available, analyses were controlled for age and gender, but not for other potential confounding factors related to occupational and non-occupational risk factors of CTS (1). Both diabetes mellitus and obesity were twice as frequent among those with CTS than in the general population of the region, which supports previous surveys of CTS (1).

Nevertheless, the prevalence of obesity and diabetes among CTS cases did not differ drastically between industries and occupations (7). The data available for the general population of this area did not allow for a more precise analysis of the relative roles of obesity and occupation in the risk of CTS. No information was available on non-occupational physical activities, such as housework, leisure, and sports activities. Some of them, such as housework among women, may be more prevalent in the lower-income categories, and therefore be a confounding factor for the association between CTS and blue-collar occupations. However, except for gender and age that were taken into account in the analyses, the non-occupational causes of CTS seem unlikely to play a major role as confounding factors (1, 2, 14).

PAF data reported in the Maine-et-Loire region should be treated with caution since the values could vary in populations with different socio-economic characteristics, depending on the proportions of blue- and white-collar workers and the sizes of the industrial sectors, even if the RR of CTS are similar (12). Nevertheless, according to the 1999 INSEE census, the socioeconomic structure of the Maine-et-Loire region is comparable to those of most French regions, except Paris. At the workplace level, the attributable risk of CTS could be different, since wide variations in exposure to work constraints may exist between companies in the same industrial sector (6).

The computation of the potential impact of intervention strategies assumed several hypotheses, namely a causal relationship between the occurrence of CTS and work exposure (1, 2, 12, 15) and a substantial impact of prevention intervention. Although multidimensional ergonomic workplace CTS intervention programs appear to be effective (1), only limited evidence of their efficacy is available (16). Moreover, insufficient information is available on the temporal and quantitative relationships between the decrease in exposure to repetitive and forceful constraints following large intervention studies, and the decrease in the incidence of CTS (1, 9, 17).

Our findings regarding the industrial sectors at high risk of CTS in the region are in line with the epidemiological literature (1, 3, 18). Work in the service industries was associated with a higher risk of CTS in women and a lower risk in men. This might be explained by the gender division of work in this sector; mostly women work in the two lowest occupational categories (at high risk of CTS), whereas many men operate in high-grade occupational categories.

The excess risk of CTS was only statistically significant for lower-grade occupational categories: blue-collar workers for men and women, and lower-grade services, sales, and clerical white-collar workers for women. The RR estimates for blue-collar workers were in the same order of magnitude as those calculated in the only

comparable study (the Montreal study) comparing the incidence of surgical release of the median nerve between manual and non-manual workers in 1994–1995 (13).

Despite its value from a public health viewpoint, very little has been published in the literature assessing the work-related PAF of CTS (19). This indicator would be valuable for public policy, because it describes the proportion of cases occurring in the population which could theoretically be avoided if the excess risk of CTS in certain industries or occupations could be lowered. Our study shows that half of all male and one fifth of female CTS cases could theoretically be avoided in the general population if CTS prevention programs were implemented for blue-collar workers. For female, lower-grade, white-collar workers, almost a quarter of cases could be avoided.

For women, the attributable proportion of CTS cases of lower-grade, white-collar workers was greater than that of blue-collar workers, despite a lower risk of CTS. Similarly, the impact of the service industries on the burden of female CTS was greater than that of the manufacturing sector. This confirms that intervention programs must be targeted not only in terms of the level of risk but also considering the number of workers involved. Our results thus suggest focusing prevention on blue-collar occupations for men, and blue-collar and overall lower-grade, white-collar occupations for women. More precisely, intervention programs should focus on the blue-collar workers of the manufacturing (for both genders) and construction sectors (for men), and on the female, lower-grade, white-collar workers of the service industries (eg, cashiers, hairdressers, nurses' aides).

In France, as in several countries, work-related musculoskeletal disorders are a national priority and many preventive intervention programs have been implemented at the corporate level. Although our study did not attempt to evaluate intervention programs, it suggests that the maximum theoretical impact of programs for prevention of CTS in the whole population might be between 5–50% if totally effective intervention programs were to be implemented in specific occupational categories or industrial sectors. However, reducing the risk of CTS in manual workers performing repetitive or forceful movements to the mean level of the general population is probably unrealistic, and more achievable objectives should probably be set (4, 5).

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