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Work-related risk factors for incidence of lateral epicondylitis in a large working population ¹

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¹ Supplementary Appendices 1 and 2

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Appendix 1: Primary analysis

This analysis was carried out on the 1384 workers without elbow pain at baseline and who were followed until the second physical examination. In this analysis, the potential risk factors for incidence are limited to self-assessment at baseline (between 2 and 9 years before the second physical examination).

Table A1-1. Univariate analyses for lateral epicondylitis													
	Complete-case analysis, N=1394 ^a												
	Men, N=797							Women, N=597					
	N	N event	% event	IRR	95% CI	P-value		N	N event	% event	IRR	95% CI	P-value
<i>Personal factors</i>													
Age, in years													
< 30	140	6	4.3	1.0	-	.		99	1	1.0	1.0	-	.
30-44	442	22	5.0	1.1	0.5- 2.9	0.76		298	17	5.7	5.6	0.7- 47.8	0.11
≥ 45	215	15	7.0	1.7	0.6- 4.4	0.29		200	10	5.0	5.0	0.6- 44.7	0.15

<i>Physical work-related factors</i>													
Doing repetitive tasks, more than 4 hours/day at first questionnaire													
No	636	30	4.7	1.0	-	.		434	15	3.5	1.0	-	.
Yes	161	13	8.1	1.7	0.9- 3.3	0.11		163	13	8.0	2.3	1.1- 4.9	0.03
Elbow -specific combined physical exposure at first questionnaire ^b													
No	562	27	4.8	1.0	-	.		451	16	3.5	1.0	-	.
Yes	235	16	6.8	1.4	0.7- 2.6	0.33		146	12	8.2	2.3	1.1- 5.0	0.03
<i>Psychosocial exposure</i>													
Low social support at first questionnaire													
No	504	23	4.6	1.0	-	.		407	18	4.4	1.0	-	.
Yes	293	20	6.8	1.5	0.8- 2.8	0.20		190	10	5.3	1.2	0.5- 2.6	0.68
^a Workers with two physical examinations													
^b High physical exertion with elbow flexion/extension more than 2 hours/day or wrist bending more than 2 hours/day													

Table A1-2. Multivariate analyses for lateral epicondylitis							
	Complete-case analysis, N=1394 ^a						
	Men, N=797				Women, N=597		
	IRR	95% CI	P-value		IRR	95% CI	P-value
Age, in years							
< 30	1.0	-	.		1.0	-	
30-44	1.2	0.5- 3.0	0.69		6.7	0.9- 49.1	0.06
≥ 45	1.9	0.7- 5.1	0.20		5.4	0.7- 41.4	0.10
Doing repetitive tasks, more than 4 hours/day at first questionnaire							
No	1.0	-	.		1.0	-	
Yes	1.7	0.8- 3.5	0.15		1.9	0.9- 4.1	0.11
Elbow -specific combined physical exposure at first questionnaire ^b							
No	1.0	-	.		1.0	-	
Yes	1.2	0.6- 2.5	0.52		2.1	1.0- 4.6	0.06
^a Workers with two physical examinations							
^b High physical exertion with elbow flexion/extension more than 2 hours/day or wrist bending more than 2 hours/day							

Appendix 2: Imputation models and procedure

Details of the multiple imputations procedure and the models performed are presented below:

- (i) The first part provides details on predictive factors in imputation models
- (ii) The second part precisely indicates which models were performed and the results obtained
- (iii) The third part describes the sensitivity analysis in detail.

Predictive factors

Auxiliary variables were needed to impute the missing data, some of which were not included in the final analysis. In the first self-administered questionnaire, we used: year of the questionnaire, department (geographical areas in Loire Valley district), body mass index in three classes (normal: <25, overweight :25-30, obesity: >30), occupations in eleven classes (low-level blue collars, high-level blue collars, blue collars supervisors, technicians supervisors, technicians, low-level civil servants, executives, high-level civil servants, employees, cleaning operatives and healthcare assistants, others/missing), socio-economic category in four classes (low-level blue collars, high-level blue collars, low-level employees, executives), type of work contract combined with working experience (permanent workers with less than 10 years of working experience, permanent workers with more than 10 years of working experience, temporary workers, agency workers), past history of upper-extremity musculoskeletal disorders (including rotator cuff syndrome, lateral epicondylitis, ulnar entrapment syndrome at the elbow, carpal tunnel syndrome, wrist tendinitis, De Quervain

disease), lifting and carrying objects in three classes (never or less than 2 hours per day, 1 to 4 kilograms more than 2 hours per day, more than 4 kilograms more than 2 hours per day). Workers with rotator cuff syndrome at the first physical examination were followed particularly closely (21) and this variable was included in the imputation models. In the second questionnaire, we used: job change since 2002 in the second period (no change; new job in the same company; new job in another company; inactive) and self-reported elbow pain. A dummy variable indicating whether or not workers attended a second physical examination was also used.

Imputation models

We used the Multiple Imputations by Chained Equation (MICE) algorithm to impute the 9 missing variables with ice command (26). This algorithm iteratively fills in each variable in cycles until convergence. The imputation models presented here were obtained by selecting variables from among 25 relevant variables described in the “predictive factors” and “risk factors” parts that could be predictive of missing values (16 variables without missing values and 9 with missing values). Particular attention was paid to use the same variables in the imputation model for outcome (lateral epicondylitis on physical examination) as in the main analysis and more generally to ensure consistency of the models between imputed variables whenever possible (congeniality, (26)). The variables included in each model are summarized in the following table (Table A2-1).

Table A2-1. Multiple imputation models for 9 variables imputed						
Imputed follow-up variables	Model	Predictive variables from first questionnaire		Predictive variables from first examination	Predictive variables from second questionnaire	Predictive variables from second examination
Job change	Multinomial logistic	Age, BMI, socioeconomic category, type of contract combined with working experience, lifting weight, repetitive action, physical exertion, elbow flexion, wrist flexion/extension, social support		Elbow pain and epicondylitis, rotator cuff syndrome	Elbow pain	Time between examinations, examination
Physical exertion	Logistic	Department, age, occupation in 11 classes, repetitive action, physical exertion, elbow flexion, wrist bending, social support	Type of contract combined with working experience, lifting weight	Elbow pain and epicondylitis, rotator cuff syndrome	Job change, physical exertion, elbow flexion, wrist flexion/extension, repetitive actions, social support, elbow pain	Elbow pain with no elbow pain at first questionnaire, time between examinations, examination
Elbow flexion			Lifting weight	Elbow pain and epicondylitis, rotator cuff syndrome		
Wrist bending			Lifting weight	Elbow pain and epicondylitis, rotator cuff syndrome		
Repetitive actions			Lifting weight	Elbow pain and epicondylitis		
Social support				Elbow pain and epicondylitis, rotator cuff syndrome		
Self-reported elbow pain	Logistic	Department, age, socioeconomic category, type contract combined with working experience, repetitive action, physical exertion, elbow flexion, wrist bending, social support		Elbow pain and epicondylitis, rotator cuff syndrome	Job change, physical exertion, elbow flexion, wrist bending, repetitive actions, social support	Elbow pain with no elbow pain at first questionnaire

Elbow pain and epicondylitis	Multinomial logistic	Age, BMI, socioeconomic category, repetitive action, physical exertion, elbow flexion, wrist bending, social support	Elbow pain and epicondylitis, rotator cuff syndrome	Physical exertion, elbow flexion, wrist bending, repetitive actions, social support, elbow pain	Elbow pain with no elbow pain at first questionnaire
Time between examinations	Normal but with predictive matching	Year of questionnaire, age, socioeconomic category, type of contract combined with working experience, repetitive actions, physical exertion, elbow flexion, wrist bending, social support	Past history of upper musculoskeletal disorders, elbow pain and epicondylitis, rotator cuff syndrome	Job change, physical exertion, elbow flexion, wrist bending, repetitive actions, social support, elbow pain	Elbow pain and epicondylitis with No Elbow pain at between examinations

The time between examinations was continuous, ranging between 2 and 9 years. This variable is non-Gaussian even after classical transformations. This problem was resolved by using a predictive matching method to avoid extreme and unrealistic values (28).

Table A2-2 shows descriptive analysis obtained from imputed data, complete-case data and available data. Subjects younger than 30 or older than 45, in lower socioeconomic categories or reporting a job change (inactive, new company) were more frequently lost to follow-up. The distributions were identical for available data and imputed data, except for time between examinations, which was accurately estimated by the year of the questionnaire and the presence of rotator cuff syndrome.

Table A2-2. Descriptive table of imputed data, available data and complete case data												
	Men						Women					
	Complete case ^a		Available data ^b		Imputed data		Complete case ^a		Available data ^b		Imputed data	
	N	%	N	%	N	%	N	%	N	%	N	%
Job change												
No change	412	72.8	714	58.0	1214.9	56.2	342	71.3	554	57.1	852.2	55.0
New job in the same company	115	20.3	217	17.6	382.8	17.7	102	21.3	163	16.8	251.0	16.2
New job in another company	30	5.3	163	13.2	335.8	15.5	18	3.8	111	11.4	206.4	13.3
Inactive	9	1.6	138	11.2	227.5	10.5	18	3.8	143	14.7	239.5	15.5
Elbow-specific combined physical exposure ^c												
No	408	72.1	920	74.7	1599.0	74.0	358	74.6	734	75.6	1191.5	76.9
Yes	158	27.9	312	25.3	562.0	26.0	122	25.4	237	24.4	357.5	23.1

Low social support												
No	318	56.2	740	60.1	1293.2	59.8	268	55.8	593	61.1	952.9	61.5
Yes	248	43.8	492	39.9	867.8	40.2	212	44.2	378	38.9	596.1	38.5
Doing repetitive tasks, more than 4 hours/day												
No	445	78.6	993	80.6	1721.7	79.7	328	68.3	702	72.3	1134. 2	73.2
Yes	121	21.4	239	19.4	439.3	20.3	152	31.7	269	27.7	414.8	26.8
Self-reported elbow pain												
No	467	82.8	990	80.8	1741.1	80.6	364	76.0	754	77.7	1215. 3	78.5
Yes	97	17.2	236	19.3	419.9	19.4	115	24.0	216	22.3	333.8	21.6
Total	566		1232		2161		480		971		1549	

^a Complete case = workers with two questionnaires and two physical examinations

^b Available case = workers with two questionnaires

^c Elbow-specific combined physical exposure = high physical exertion with elbow flexion/extension more than 2 hours/day or wrist bending more than 2 hours/day

	Men						Women					
	Complete case ^a		Available data ^b		Imputed data		Complete case ^a		Available data ^b		Imputed data	
	N	%	N	%	N	%	N	%	N	%	N	%
Lateral epicondylitis at second examination												
No elbow pain	480	84.8	784	85.1	1844.4	85.4	404	84.2	586	84.9	1305.0	84.3
Elbow pain only	44	7.8	71	7.7	165.7	7.7	49	10.2	64	9.3	149.8	9.7
Lateral epicondylitis	42	7.4	66	7.2	151.0	7.0	27	5.6	40	5.8	94.3	6.1
Time between examinations												
2 to 4 years	66	11.7	126	13.7	221.0	10.2	52	10.8	84	12.2	159.5	10.3
4 to 6 years	295	52.1	480	52.1	1025.2	47.4	264	55.0	370	53.6	790.1	51.0
6 to 9 years	205	36.2	315	34.2	914.8	42.3	164	34.2	236	34.2	599.5	38.7
Total	566		921		2161		480		690		1549	
^a Complete case = workers with two questionnaires and two physical examinations												
^b Available case = workers with two physical examinations												

Missingness mechanism and sensitivity analyses

It was assumed, in this paper, that data were missing at random, i.e. sufficient information concerning the missingness mechanism was available with the observed variables (26). A sensitivity analysis assumes that the missing mechanism is missing not at random (i.e. depends on unobserved variables) using specific assumptions. Here, variation of the missingness mechanism for physical examination only was explored since the lateral epicondylitis was the variable of interest; this is an important restriction because the missingness mechanism for the second questionnaire could also be missing not at random ([this assumption was not explored here](#)). Usually, two types of methods can be used to perform missing not at random analyses: pattern mixture models and selection models. Here, the not at random analyses were performed by adding an offset to the last prediction of the multiple imputation model; this is close to the pattern mixture model and was suggested by what can be done when only one binary variable is missing (35). Although we tried, as far as possible, to take relevant variables into account in imputation models, some data were not measured, particularly the health status for workers lost to follow-up (which could be poorer than that of workers who completed follow-up) and the employment situation at the second phase of the study (workers lost to follow-up may have presented a less favourable employment situation). Auxiliary information was available concerning the missingness mechanism that was classified into three types: no appointment during the period 2007-2010, change of situation (change of address, dismissal, disability, time off work, retirement) or unknown cause. In the initial imputation model, in which an MAR mechanism was assumed, the prevalence of

epicondylitis was similar between the three categories of causes (rough proxy for working conditions or health status) and the effect of age (rough proxy for chosen or imposed employment status) was assumed to be identical between categories.

Sensitivity analyses investigated two types of scenarios with several assumptions. The first type of scenario assumed that the prevalence of epicondylitis at the second examination among workers with a change of situation or with unknown cause of missingness was higher than among workers who completed follow-up and that the prevalence among workers without an appointment was lower than among workers who completed follow-up. Workers with a high risk of developing musculoskeletal disorders were probably followed more frequently than other workers (workers were expected to be at lower risk when no appointment was made); any change in situation could indicate poor working conditions and workers in poor health (a change of situation could indicate that workers were at greater risk). The second type of scenario assumed, in addition to the previous assumptions, is that the effect of age on prevalence was higher among workers with a change of situation or with no known cause of missingness than among workers who completed follow-up and that the effect of age on prevalence was lower among workers without an appointment than among workers who completed follow-up, as the effect of age could be a proxy for susceptibility to imposed job change (a job change after the age of 45 years would be more frequently imposed than between the ages of 30 and 44 years) or health status (a worker older than 45 without an appointment could be healthier than workers older than 45 who completed follow-up). Using the maximal prevalence reported in the literature for elbow pain and epicondylitis, the models were adapted to obtain a prevalence at the second physical examination ranging between 0% and 10% (up to 15% for older workers). The

assumptions for the effect of age were odds-ratios for each class between 1.5 and 5 (in table A2-4, the resulting prevalences in each class are indicated). The main results are summarized below, i.e. multivariate analysis with multiple imputations on model 3 on the main categories of interest (for age, effect on workers aged “45 years and older” versus “younger than 30 years” and for elbow-specific combined physical exposure and repetitive tasks, “exposed at both questionnaires” versus “never exposed”, Tables A2-3 and A2-4). Very robust results were obtained for each type of change in prevalence according to the scenarios considered.

Table A2-3. Sensitivity analysis on global prevalence using cause of missingness							
	Prevalences at second physical examination				IRR of higher vs lower exposure		
	No appointment	Change in situation	Unknown	Not missing	Age	Elbow-specific	Repetitive task
Men							
<i>Basic imputations (MAR)</i>	7	8	6	7	2.2 (0.9-5.4)	2.7 (1.2-6.0)	1.9 (0.8-4.6)
Low scenario ¹	0	8	6	7	2.2 (1.0-4.9)	2.5 (1.2-5.3)	1.7 (0.7-3.8)
Plausible scenario ²	3	10	8	7	2.1 (1.0-4.5)	2.5 (1.2-4.9)	1.9 (0.9-3.8)
High	7	10	10	7	1.7 (0.9-3.2)	2.3 (1.2-4.4)	1.7 (0.9-3.2)

scenario ³							
Extreme scenario ⁴	0	10	10	7	1.7 (0.8-3.3)	2.0 (1.0-3.9)	1.6 (0.8-3.2)
Women							
<i>Basic imputations (MAR)</i>	7	7	6	6	6.4 (0.8-51.9)	2.9 (1.2-7.4)	1.5 (0.5-4.5)
Low scenario ¹	0	7	5	6	6.7 (1.1-40.9)	2.7 (1.1-6.6)	1.3 (0.5-3.6)
Plausible scenario ²	3	10	8	6	3.6 (1.0-13.0)	2.8 (1.3-6.0)	1.3 (0.6-3.3)
High scenario ³	6	10	10	6	2.7 (0.9-8.1)	2.5 (1.2-5.1)	1.3 (0.6-2.9)
Extreme scenario ⁴	0	10	10	6	2.5 (0.8-8.2)	2.1 (0.9-4.8)	1.2 (0.5-3.1)
¹ No cases if no appointment, initial prevalence for 2 other causes of missingness ² Lower prevalence if no appointment, higher for 2 other causes of missingness (particularly for change in situation) ³ Initial prevalence if no appointment, higher for 2 other causes of missingness ⁴ No cases if no appointment, higher for 2 other causes of missingness							

Table A2-4. Sensitivity analysis on global prevalence using cause of missingness and age												
	Prevalences at second physical examination									IRR of higher vs lower exposure		
	No appointment			Change in situation			Not know			Age	Elbow-specific	Repetitive task
	<30 years	30-44 years	≥45 years	<30 years	30-44 years	≥45 years	<30 years	30-44 years	≥45 years			
Men												
<i>Basic imputations</i>	4	7	10	8	8	9	4	6	8	2.2 (0.9-5.4)	2.7 (1.2-6.0)	1.9 (0.8-4.6)
Plausible scenario ¹	1	3	5	5	10	15	4	8	12	3.0 (1.4-6.5)	2.4 (1.2-4.8)	1.9 (0.9-3.9)
Moderate scenario ²	0	0	2	3	8	13	2	6	10	3.7 (1.6-8.7)	2.5 (1.2-5.3)	1.7 (0.8-3.8)
Low scenario ³	0	0	2	6	8	10	4	6	8	2.6 (1.1-5.9)	2.5 (1.2-5.2)	1.7 (0.8-3.8)
Women												

<i>Basic imputations</i>	1	9	8	2	8	8	1	9	7	6.4 (0.8-51.9)	2.9 (1.2-7.4)	1.5 (0.5-4.5)
Plausible scenario ¹	1	3	5	5	10	15	4	8	12	3.8 (1.1-13.6)	2.7 (1.2-6.2)	1.4 (0.6-3.4)
Moderate scenario ²	0	0	2	2	7	12	2	6	10	6.6 (1.3-33.3)	2.7 (1.2-6.3)	1.4 (0.6-3.7)
Low scenario ³	0	0	2	5	7	9	4	6	8	3.2 (0.9-11.1)	2.7 (1.2-6.2)	1.4 (0.5-3.8)
¹ Plausible prevalence among 30-44 years, lower effect of age if no appointment and higher effect for other causes of missingness ² Low prevalence among 30-44 years, lower effect of age if no appointment and higher effect for other causes of missingness ³ Low prevalence among 30-44 years, low effect of age												