The assessment of the Healthy Worker Survivor Effect in the relationship between psychosocial work-related factors and hypertension

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Abstract

Objectives: The Healthy Worker Survivor Effect (HWSE) usually leads to underestimation of the effects of harmful occupational exposures. The HWSE is characterized by the concomitance of three associations: 1) Job status - subsequent exposure, 2) job status - disease, 3) previous exposure – job status. No study has reported the coexistence of these associations in the relationship between psychosocial work-related factors and health. We assessed if the HWSE is present when measuring the effects of cumulative exposure to psychosocial work-related factors on the prevalence of hypertension in white-collar workers. **Methods**: Data were obtained from two time-points (1991-1993 at baseline and 1999-2001 at follow-up) of a prospective cohort study. At baseline, the population was composed of 9188 white-collar employees (women: 49.9%) in Quebec City. Job strain as psychosocial work-related factor and blood pressure were measured using validated methods. Job status (retirees vs. employees) at follow-up was self-reported. Multiple multilevel robust Poisson regressions were used to estimate prevalence ratios of hypertension and risk ratios of retirement separately by gender. We performed multiple imputations to control selection bias due to missing values.

Results: Retirement eliminated the subsequent exposure to job strain de facto and was associated with the reduction in the prevalence of hypertension in younger (-33%) and older (-11%) men and in older women (-39%). Job strain was associated with job status in younger men and in women of any age. **Conclusion**: Data showed the presence of HWSE in younger men and older women given the coexistence of the three structural associations.

Key messages

What is already known about this subject?

►Any occupational study on workers' health could potentially face the Healthy Worker Survivor Effect (HWSE). If inadequate statistical methods are used, the HWSE usually leads to underestimation of the effects of possibly harmful occupational exposures. The HWSE has never been empirically investigated with respect to psychosocial work-related factors.

What are the new findings?

►We assessed the presence of the HWSE in the relationship between cumulative exposure to job strain and hypertension. The HWSE was present especially in younger men and older women.

How might this impact on policy or clinical practice in the foreseeable future?

►The HWSE may contribute to underestimating the true impact of work-related psychosocial factors on health. This will in turn underestimate the true potential health benefits that would result from reducing these exposures by primary prevention efforts. The assessment of the HWSE should precede any evaluation of the relationship between occupational exposures and health in order to guide the choice of adequate statistical approaches.

INTRODUCTION

The Healthy Worker Survivor Effect (HWSE) refers to a selection process wherein people who remain employed are generally healthier than those who leave work (1-3). In studies of the effect of cumulative exposure to occupational factors on health, the HWSE bias results from less healthy workers who leave job accumulate less exposure than workers who remain. The HWSE bias can distort the true exposure-response relationship downward toward the null or beyond (1, 4). Structurally, the HWSE is characterized by the coexistence of three associations (figure 1): job status - subsequent exposure, job status - outcome, and previous exposure - job status (4, 5). Such a structure corresponds to time-varying confounding since *job status* acts as both a confounding and an intermediate variable (2, 6, 7). This dual role imposes the difficult decision of whether or not to adjust for job status given that both choices may yield biased estimates (3-5). Thus, conventional analytical methods (such as adjustment for time-since-hire or adjustment for active job status) do not adequately control the HWSE and may introduce bias (1-3, 8). It is recommended to use alternative methods known as *g-methods* (such as inverse probability weighting, g-estimation and g-formula) (9).

The HWSE varies from one cohort to another according to sociodemographic, employment, and time-related factors (10). It is recommended to first evaluate the potential for the HWSE when analyzing data from occupational cohorts (4). A simple way to do so is to assess the three associations that compose the HWSE (5). Such an evaluation guides the choice of an appropriate analytical approach (4, 5).

To our knowledge, only three studies have reported the structural components of the HWSE (4, 5, 11). The first two studies concerned the effects of chemical exposure (4, 5) and the third one investigated the effects of specific jobs (11). Despite the fact that psychosocial work-related factors (PWF) have been studied repeatedly, the potential of the HWSE in such studies has not been empirically evaluated. We thus aimed to assess the presence of the HWSE when measuring the effects of cumulative exposure to PWF on hypertension in white-collar workers. Specifically, we investigated the associations i) job status - hypertension, ii) previous PWF - job status. The association job status -

subsequent PWF was assumed to be present since the measure of the exposure is not applicable to individuals who have left employment.

METHODS

Population and study design

Data were obtained from two time-points (1991-1993, at baseline and 1999-2001, at follow-up) of the PROspective Québec (PROQ) Study on Work and Health led by Brisson (12). At baseline, all white-collar workers employees in 19 public organizations in Quebec City aged 18 to 65 years old were invited to participate. A total of 9188 employees (75%) from the target population accepted the invitation. When evaluating the association previous PWF - job status, we included all the 9188 participants at baseline except people aged less than 32 years at baseline (n=1433), pregnant women at baseline or follow-up (n=53), people with different job status than employee or retiree at follow-up (n=3 trainees, 46 unemployed people and 70 individuals with other job statuses) and prevalent hypertension cases at baseline (n=1172). A total of 6411 individuals (women: 51.2%) was analysed for the association previous PWF-job status. When evaluating the association job status - hypertension, we further excluded participants at baseline that did not participate at follow-up (n=616). In total, 5795 individuals (women: 50.6%) were analysed for the association job status-hypertension. People aged less than 32 years at baseline were excluded to avoid positivity issues (association job status – hypertension) and to consider the same population in all analyses.

Data collection and variables

At baseline and follow-up, workers completed a self-administered questionnaire on demographic characteristics, biological and behavioural risk factors for hypertension and cardiovascular diseases (CVD), family and personal history of CVD, job status, characteristics of work and social life. Trained staff measured blood pressure, weight, height, and waist circumference using validated protocols (13, 14).

Hypertension

In accordance with the American Heart Association protocol (13), resting blood pressure was measured after workers had been sitting for 5 minutes using a mercury sphygmomanometer. Two (at baseline) or three (at follow-up) measurements of blood pressure were taken, 1 to 2 minutes apart. The averages of the blood pressure measurements were used as blood pressure levels. Hypertension cases included both untreated individuals with high blood pressure levels (≥ 140/90 mm Hg) and individuals taking antihypertensive medication. The proportion of hypertension at follow-up was estimated by the ratio of the number of hypertension cases on the total number of participants at follow-up.

Psychosocial work-related factors: job strain

Both components of Karasek's job strain model were measured at baseline and follow-up using 18 items from the Job Content Questionnaire (15). Psychological demand refers to the quantity of work, time constraints, and level of intellectual effort required. Decision latitude refers to opportunities for learning, autonomy, and participation in the decision-making process. Previous studies have demonstrated the psychometric validity of the original complete Job Content Questionnaire scale of 18 items (16) and its French version (17). At both baseline and follow-up, we have used the quadrant method to classify participants in four groups. Workers with psychological demand scores of 24 or higher (the median for the general Quebec working population) were classified as having high demand. Workers with decision latitude scores of 72 or lower (the median of general Quebec working population) were classified as having low latitude (14). The job strain groups were formed of workers with low demand and high latitude (low strain), low demand and low latitude (passive), high demand and high latitude (active), and high demand and low latitude (high strain). In the current study, PWF were measured by job strain.

Job status

Job status (retirees versus employees) at follow-up was self-reported using the question: "What is your current employment status?". Retirees included individuals who checked the "retired" response and employees include all individuals who checked the corresponding options (casual or permanent employees).

Statistical analyses

We used multilevel robust Poisson regression, with clustering for organizations, to estimate prevalence ratios (PR) of hypertension (yes vs. no) according to job status (retirees vs. employees) at follow-up and risk ratios (RR) of retirement at follow-up according to previous exposure to job strain (low strain, passive, active or high strain) at baseline. We adjusted models for known determinants of blood pressure and retirement including demographic (age, completed education, annual household income, living with a partner) and biological factors (diabetes, cholesterol, waist circumference, Body Mass Index), lifestyle (alcohol abuse, daily smoking, leisure physical activity), other work-related factors (hours worked per week for the organization, hours worked per week for another organization), non-work-related factors (number of children at home), personal, and family history of CVD (see Table 1 for variables categorization). Models also included systolic and diastolic blood pressure for the association previous job strain - job status and previous job strain for the association job status -hypertension. Potential confounders were measured at baseline, and therefore were considered not to be potential mediators. Separate models were fit by gender.

More than 20% of observations had missing data for at least one variable, suggesting a relatively high potential for selection bias if performing a complete case analysis. All variables had missing data, except gender, age, systolic and diastolic blood pressure and personal history of CVD. Subjects with and without missing data differed according to several characteristics (see Table S1 in supplement). To control the potential selection bias due to missing data, we performed multiple imputations by chained equations under a missing at random assumption. All variables with missing values were imputed based on the rest of the variables in the model. According to White's rule (18), we performed between 26 and 53 imputations per analysis (see the exact number in tables 2 to 4). Given the potential for selection bias in non-imputed analyses, we focus the interpretation on associations measured using the imputed data.

The level of statistical significance was set at 0.05. The determination of the presence of the associations that compose the HWSE was based primarily on the magnitude of the associations. Statistical significance was considered as an accessory criterion given its dependence on the sample size (19). In addition, it was observed that the performance of standard methods to control the HWSE is inversely proportional to the magnitude of the associations that compose it (20). All analyses were performed with SAS 9.4 software. The associations are presented with confidence intervals at 95% (CI 95%).

RESULTS

There was 18.3% of hypertension cases at follow-up in men (n=3132) and 11.5% in women (n=3279). Table 1 presents the population characteristics at baseline according to job status at follow-up. The proportion of retirees at follow-up was 17.9% in men and 9.7% in women. In both genders, retirees differed from employees on a number of characteristics. Age and waist circumference were on average higher in retirees. The proportions of individuals with, personal and familial history of CVD were also higher among retirees. On the other hand, the proportions of people with a University diploma, at least one child at home and high strain were lower in retirees. In both genders, the frequency of retirements evolved into a bell-shaped pattern between the years 1991 and 2003, with a peak in 1996 in men (28.4%, n=454) and 1997 in women (26.1%, n=249) (see figure in supplement).

Table 1. Baseline characteristics of participants according to job status in men and women (n=6411)

	Men 3132 (48.9%)			Women 3279 (51.2%)		
	Missing (%)	Retirees	Employees	Missing (%)	Retirees	Employees
		505 (17.9%)	2323 (82.1%)		277 (9.7%)	2592 (90.4%)
Age y, mean (SD)	304 (9.7)	53.3 (5.1)	40.8 (5.2)	410 (12.5)	52.1 (5.7)	38.9 (4.9)
Completed education	325 (10.4)			428 (13.1)		
Secondary or less		107 (21.6)	300 (13.0)		161 (59.2)	1199 (46.5)
Collegial		112 (22.6)	576 (24.9)		76 (27.9)	708 (27.5)
University		277 (55.9)	1435 (62.1)		35 (12.9)	672 (26.1)
Household income $C[a]	324 (10.3)			456 (13.9)		
0 - 39 999		65 (13.1)	333 (14.4)		108 (40.0)	770 (30.2)
40 000 - 69 999		243 (48.9)	1121 (48.5)		107 (39.6)	1124 (44.0)
≥ 70 000$		189 (38.0)	857 (37.1)		55 (20.4)	659 (25.8)
Living with a partner	333 (10.6)			432 (13.2)		
yes		426 (85.5)	1892 (82.2)		163 (60.2)	1823 (70.8)
No		72 (14.5)	409 (17.8)		108 (39.9)	753 (29.2)
Diabetes	321 (10.2)			425 (13.0)		
Yes		28 (5.6)	33 (1.4)		9 (3.3)	42 (1.6)
No		473 (94.4)	2277 (98.6)		264 (96.7)	2539 (98.4)
High cholesterol	323 (10.3)			436 (13.3)		
Yes		173 (34.8)	449 (19.4)		56 (21.0)	210 (8.2)
No		324 (65.2)	1863 (80.6)		211 (79.0)	2366 (91.9)
Waist circumference cm, mean (SD)	312 (10.0)	93.1 (9.5)	89.4 (8.5)	427 (13.0)	78.4 (11.7)	73.9 (9.5)
Body Mass Index kg/m2, mean (SD)	314 (10.0)	26.0 (3.5)	25.2 (3.3)	426 (13.0)	25.0 (3.9)	23.5 (3.9)
Alcohol abuse	317 (10.1)			427 (13.0)		
Yes[b]		28 (5.6)	114 (4.9)		8 (2.9)	79 (3.1)
No		471 (94.4)	2202 (95.1)		267 (97.1)	2498 (96.9)
Daily smoking	313 (10.0)			419 (12.8)		

Yes		95 (19.0)	371 (16.0)		44 (16.0)	547 (21.2)
No		406 (81.0)	1947 (84.0)		231 (84.0)	2038 (78.8)
Physical activity[s]	312 (10.0)			418 (12.7)		
Yes		261 (51.9)	1030 (44.5)		103 (37.2)	937 (36.3)
No		242 (48.1)	1287 (55.6)		174 (62.8)	1647 (63.7)
Children at home	325 (10.4)			443 (13.5)		
One or more		276 (55.3)	1616 (70.0)		95 (34.8)	1666 (65.0)
No		223 (44.7)	692 (30.0)		178 (65.2)	897 (35.0)
Job strain	325 (10.4)			448 (13.7)		
Low strain		116 (23.3)	432 (18.7)		34 (12.7)	325 (12.7)
Passive		196 (39.4)	772 (33.4)		151 (56.6)	1220 (47.6)
Active		116 (23.3)	670 (29.0)		30 (11.2)	424 (16.5)
High strain		69 (13.9)	436 (18.9)		52 (19.5)	595 (23.2)
hours worked per week for the organization	307 (9.8)			419 (12.8)		
≤40		433 (86.1)	2059 (88.7)		263 (96.0)	2475 (95.7)
> 40		70 (13.9)	263 (11.3)		11 (4.0)	111 (4.3)
hours worked per week for another organization	509 (16.3)			587 (17.9)		
0		341 (74.5)	1552 (71.7)		214 (84.9)	1951 (80.0)
≥ 1		117 (25.6)	613 (28.3)		38 (15.1)	489 (20.0)
Personal history of CVD[d]	304 (9.7)			410 (12.5)		
Yes		35 (6.9)	48 (2.1)		12 (4.3)	53 (2.0)
No		470 (93.1)	2275 (97.9)		265 (95.7)	2539 (98.0)
Familial history of CVD[e]	673 (21.5)			795 (24.2)		
Yes		175 (43.0)	729 (35.5)		114 (53.5)	938 (41.3)
No		232 (57.0)	1323 (64.5)		99 (46.5)	1333 (58.7)

[a] Canadian dollars
[b] 10 or more drinks a week in women or 15 or more drinks a week in men
[c] Performed leisure physical activity one time or less a week
[d] the person has had a cardiac medical problem (angina, myocardial infarction, coronary bypass) or a stroke (paralysis, embolism, hemorrhage, thrombosis)
[e] A member of the immediate family (father, mother, brother, or sister) has had a cardiac medical problem (angina, myocardial infarction, coronary bypass) or a stroke (paralysis, embolism, hemorrhage, thrombosis) under the age of 60 years.

Table 2 presents the association job status - hypertension at follow-up (component 2). In general, the trend of results in the fully adjusted model before imputation is maintained after imputation, except for women aged less than 50 years (the prevalence ratio is less than 1 before imputation and increases to 1 after imputation). Due to the reduced number of cases, it was impossible to measure the association job status - hypertension in women aged 50 years and over using the non-imputed data. The fully adjusted imputed models show that the prevalence of hypertension is lower in retirees compared to employees, except for women aged less than 50 years for whom we do not observe an association. No association measured after imputation is statistically significant.

Table 2. Prevalence ratios of hypertension according to job status at follow-up in men and women

	n	Hypertension (%)	No imputation			Multiple imputation	
			PR (CI 95%)[ab]	PR (CI 95%)[ac]	Observations with missing values (%)[d]	PR (CI 95%)[ac]	Number of imputations
People of all ages							
Men					788 (27.5)		28
Employees	2257	391 (17.3)	1.00	1.00		1.00	
Retirees	471	109 (21.8)	0.91 (0.67-1.22)	0.90 (0.67-1.21)		0.88 (0.65-1.18)	
Women					879 (30.0)		30
Employees	2509	259 (10.3)	1.00	1.00		1.00	
Retirees	245	55 (22.5)	0.80 (0.59-1.1)	0.61 (0.37-1.01)		0.75 (0.50-1.11)	
People aged < 50 years old							
Men					588 (25.1)		26
Employees	2136	365 (17.1)	1.00	1.00		1.00	
Retirees	113	18 (15.9)	0.78 (0.45-1.35)	0.68 (0.36-1.30)		0.75 (0.46-1.24)	
Women					753 (28.3)		29
Employees	2432	237 (9.8)	1.00	1.00		1.00	
Retirees	84	19 (22.6)	1.16 (0.76-1.78)	0.82 (0.39-1.74)		1.00 (0.58-1.72)	
People aged ≥ 50 years old							
Men					200 (38.5)		39
Employees	121	26 (21.5)	1.00	1.00		1.00	
Retirees	358	91 (25.4)	0.98 (0.67-1.41)	0.98 (0.72-1.32)		0.90 (0.56-1.45)	
Women					126 (45.5)		46
Employees	77	22 (28.6)	1.00	No convergence due to the reduced number of cases		1.00	
Retirees	161	36 (22.4)	0.71 (0.48-1.05)			0.72 (0.39-1.32)	

[a] Prevalence ratio and 95% confidence interval
[b] Adjusted for age at baseline
[c]Fully adjusted model (for age, completed education, household income, living with a partner, diabetes, high cholesterol, waist circumference, Body Mass Index, alcohol abuse, daily smoking, leisure physical activity, children at home, job strain, hours worked per week for the organization, hours worked per week for another organization, personal history of CVD, familial history of CVD at baseline)
[d]Number and percentage of observations with missing values when performing the fully adjusted non-imputed model

The association previous job strain at baseline - job status at follow-up (component 3) is presented in Table 3. In individuals of any age, fully adjusted models show no association between job strain and employment status in men before and after imputation, with risk ratios of retirement equal or close to 1. In women the general trend of the results is maintained before and after imputation except in passive group (risk ratio greater than 1 before imputation and equal to 1 after imputation). The fully adjusted imputed model shows a reduction of the risk of retirement in active and high-strain women compared to the unexposed group (low strain). There is almost no difference between the passive and the unexposed women.

Table 3. Risk ratios of retirement at follow-up visit according to previous exposure to job strain at baseline in men and women

	n	Retirement (%)	No imputation			Multiple imputation	
			RR (CI 95%)[ab]	RR (CI 95%)[ac]	Observations with missing values (%)[d]	RR (CI 95%)[ac]	Number of imputations
Men					983 (31.4)		32
Job strain							
Low strain	548	116 (21.2)	1.00	1.00		1.00	
Passive	968	196 (20.3)	1.01 (0.95-1.07)	0.98 (0.90-1.06)		0.99 (0.94-1.04)	
Active	786	116 (14.8)	1.00 (0.95-1.05)	1.01 (0.94-1.08)		0.99 (0.94-1.04)	
High strain	505	69 (13.7)	1.00 (0.95-1.05)	0.97 (0.91-1.03)		0.99 (0.96-1.04)	
Women					1123 (34.2)		35
Job strain							
Low strain	359	34 (9.5)	1.00	1.00		1.00	
Passive	1371	151 (11.0)	1.03 (0.93-1.14)	1.12 (0.94-1.34)		1.00 (0.71-1.39)	
Active	454	30 (6.6)	0.93 (0.82-1.05)	0.94 (0.74-1.21)		0.93 (0.60-1.44)	
High strain	647	52 (8.0)	0.96 (0.87-1.06)	0.98 (0.84-1.13)		0.93 (0.64-1.37)	

[a] Risk ratio and 95% confidence interval
[b] Adjusted for age at baseline
[c] Fully adjusted model (for age, completed education, household income, living with a partner, diabetes, high cholesterol, waist circumference, Body Mass Index, alcohol abuse, daily smoking, leisure physical activity, children at home, hours worked per week for the organization, hours worked per week for another organization, personal history of CVD, familial history of CVD, systolic blood pressure, diastolic blood pressure at baseline)
[d] Number and percentage of observations with missing values when performing the fully adjusted non-imputed model

Table 4 presents the association previous job strain - job status stratified by age at baseline. In the group aged less than 50 years, the trend of fully adjusted model results is preserved before and after imputation, except for active women (risk ratio less than 1 before imputation and greater than 1 after imputation). Regardless of job strain level, exposed people have a lower risk of retirement than the unexposed in men. In women, the risk of retirement is lower for those with high strain compared to the unexposed, while passive or active women are at higher risk. In the group aged 50 years and over, the risk ratios of retirement in men before and after imputation are close to 1 except for those with high strain (risk ratio of 0.88 before imputation and 1 after imputation). In women, modelling retirement in the fully adjusted model without imputing was impossible because of the lack of convergence due to the reduced number of cases. The fully adjusted imputed models shows a reduction of the risk in active and high strain women compared to the unexposed group, while passive women have a higher risk. No association measured for component 3 is statistically significant.

Table 4. Risk ratios of retirement at follow-up visit according to previous exposure to job strain at baseline among men and women by age

	n	Retirement (%)	No imputation			Multiple imputation	
			RR (CI 95%)[ab]	RR (CI 95%)[ac]	Observations with missing values (%)[d]	RR (CI 95%)[ac]	Number of imputations
People aged < 50 years old							
Men					721 (28.5)		29
Job strain							
Low strain	433	28 (6.5)	1.00	1.00		1.00	
Passive	777	47 (6.1)	1.00 (0.67-1.48)	0.70 (0.43-1.15)		0.88 (0.58-1.42)	
Active	668	31 (4.6)	0.84 (0.55-1.29)	0.70 (0.43-1.15)		0.81 (0.48-1.35)	
High strain	433	18 (4.2)	0.81 (0.50-1.30)	0.71 (0.43-1.16)		0.74 (0.41-1.33)	
Women					942 (32.1)		33
Job strain							
Low strain	323	11 (3.4)	1.00	1.00		1.00	
Passive	1237	52 (4.2)	1.38 (0.69-2.76)	1.33 (0.70-2.55)		1.13 (0.60-2.09)	
Active	427	16 (3.8)	1.40 (0.62-3.19)	0.91 (0.38-2.18)		1.36 (0.66-2.83)	
High strain	592	16 (2.7)	0.95 (0.42-2.12)	0.72 (0.36-1.44)		0.91 (0.44-1.88)	
People aged ≥ 50 years old							
Men					262 (43.7)		44
Job strain							
Low strain	115	88 (76.5)	1.00	1.00		1.00	
Passive	191	149 (78.0)	1.02 (0.87-1.20)	0.99 (0.83-1.18)		1.01 (0.78-1.30)	
Active	118	85 (72.0)	1.02 (0.87-1.20)	1.03 (0.88-1.20)		1.04 (0.77-1.40)	
High strain	72	51 (70.8)	1.02 (0.89-1.16)	0.88 (0.77-1.01)		1.00 (0.72-1.40)	
Women					181 (52.8)		53
Job strain				No convergence due to the reduced number of cases			
Low strain	36	23 (63.9)	1.00			1.00	
Passive	134	99 (73.9)	1.05 (0.84-1.31)			1.04 (0.68-1.58)	
Active	27	14 (51.9)	0.78 (0.60-1.01)			0.77 (0.42-1.42)	
High strain	55	36 (65.5)	1.00 (0.85-1.18)			0.95 (0.59-1.54)	

[a] Risk ratio and 95% confidence interval
[b] Adjusted for age
[c] Fully adjusted model (for age, completed education, household income, living with a partner, diabetes, high cholesterol, waist circumference, Body Mass Index, alcohol abuse, daily smoking, leisure physical activity, children at home, hours worked per week for the organization, hours worked per week for another organization, personal history of CVD, familial history of CVD, systolic blood pressure, diastolic blood pressure at baseline)
[d] Number and percentage of observations with missing values when performing the fully adjusted non-imputed model

DISCUSSION

We assessed the presence of the HWSE in the relationship between cumulative exposure to job strain (at baseline and follow-up) and hypertension (at follow-up) in white-collar workers by evaluating the structural components associations. The HWSE was present in men and women, especially in younger men and older women.

The association job status - subsequent job strain was considered to be present based on the assumption that being retired eliminates the possibility of being exposed subsequently to occupational factors (4, 5). This assumption may not be true for everyone, since returning to work after retirement is possible. Nevertheless, retirement greatly reduces the probability of subsequent PWF. As such, we argue that the association job status - subsequent job strain is indeed present.

Regarding the effect of job status on the prevalence of hypertension, we observed a protective association of retirement on hypertension, except in younger women who showed no association. These observations are consistent with previous studies. A protective association was found between retirement and physical and mental health in Australian women (21). Data from 12 countries in Western Europe showed a protective association of retirement with health in both genders (22). However, there is also evidence suggesting no effect of retirement on health (21, 23-25). Ekerdt and al. observed no association between retirement and the incidence of hypertension (odds ratio: 0.9 (95% CI: 0.6-1.5)) (24). No significant association was found between retirement, physical health (23) and chronic diseases such as diabetes and coronary heart disease (25). Retirement is an important step that can affect health differently based on personal characteristics such as personality, social and material conditions, job characteristics and whether or not individuals are voluntarily retired (26). A beneficial effect on physical health is possible through the reduction of job stress and the adoption of healthy lifestyle (27). On the other hand, a deleterious effect can occur through the loss of a valued job and the adoption of unhealthy lifestyle (22, 27).

The effect of retirement on hypertension is probably underestimated due to the presence of non-differential misclassification of retirement with respect to hypertension. Retirees formed a heterogeneous group, including those who have genuinely retired and those who may have another job. Compared with women, the risk of such a misclassification is probably higher among male retirees due to their greater susceptibility to return to work (28). Such a misclassification is likely to underestimate associations. The lack of information on the current occupation of retirees has limited our ability to categorize more appropriately.

With respect to the association previous job strain - job status we found a protective association in younger men while we observed no association in older men. In women, there were also variations according to age. In younger women, those with passive or active job were at higher risk of retirement compared to the unexposed while the risk was lower in women exposed to high strain. In older women, exposure to active job was associated with a lower risk of retirement. Risk differences associated with exposure to passive (deleterious association) or high strain (protective association) jobs were relatively small. Previous studies are not unanimous depending on the characteristics of the populations and the types of PWF. It was found that low control combined with high demand was associated with a higher risk of early retirement for individuals in managerial, technical and professional occupations but no significant associations were observed for other occupations such as clerical, sales, blue-collar (29). Among civil servants, high skill discretion was associated with a lower risk of retirement while no association was observed for low job demand and high decision authority (30). High job strain, demand, latitude and social support were not significantly associated with retirement in men and women in the 1958 birth cohort (31).

Many factors including demographic factors, health, social factors, social participation, work characteristics, financial factors, retirement preferences, and macro or country level factors can influence retirement in industrialised countries (32). Theoretically, the components of job strain model can influence retirement by several mechanisms. Prolonged exposure to high demand can increase the risk of retirement by promoting physical and mental exhaustion and reducing job satisfaction. High latitude can reduce the risk of retirement by increasing job satisfaction. In addition, high latitude can moderate the effects of high demand on retirement (33).

People retired early in our study. This can be explained by the popularity of early retirement incentives offered in the mid-1990s by the Quebec government in order to reduce wage cost (34, 35). The lowering in 1987 of the minimum age at which one could benefit from the Canada Pension Plan (from 65 to 60 years old) also contributed to early retirement (34).

In the current study, previous job strain was not associated with retirement in older men. Some evidence suggests that workers consider their profession as demanding mainly due to the physical workload whatever the profession. It was observed that office workers perceived their profession as not demanding, in contrast to the construction workers and firefighters (36). Moreover, the frequency of retirement differs between professions. The incidence of voluntary retirement was higher in blue-collar and lower-level white-collar workers compared to higher-level white-collar workers (37). Job strain may not be a major determinant for retirement particularly in male older white-collar workers, who are probably more experienced at managing psychosocial job stress. In this group of employees, other factors such as health status and financial reasons may predominate with respect to retirement. We observed that job strain was associated with a lower risk of retirement in younger men. One can understand that retirement is generally not an option for younger men given their age. The peak in retirement we observed in 1996 and 1997 is probably due to the Quebec government early retirement incentives mentioned above (34, 35). We observed the impact of this peak on the association previous job strain - job status in active or passive younger women who presented a higher risk of retirement despite their relatively early age. We did not observe any impact of this peak in men and older women.

Job status and hypertension were both assessed at the same timepoint, at follow-up. This limits our ability in establishing temporality and can lead to reverse causality bias. The exclusion of hypertensive people at baseline allowed reducing such drawbacks.
We used a single measure of previous exposure to job strain without taking into account the frequency and duration. This may have led to a non-differential misclassification of job strain with respect to job status that may underestimate the effect on retirement.

We evaluated the HWSE for a period of on average 8 years. It is likely that the presence of the HWSE could be stronger for a longer observation period due to increased selection processes over time. Future studies with a longer follow-up are needed.

To our knowledge, the current study is the first to assess the HWSE with respect to PWF. There are several strengths including separate analyzes by gender, a large sample size with good precision indicated by narrow confidence intervals for non-stratified analyzes, good participation at baseline and follow-up, the use of multiple imputations to control selection bias due to missing values and exclusions. The present study has also some limitations. First, the use of self-reported job status can lead to misclassification of the retirees group and to the risk of underestimating effects. Second, we evaluated the association previous job strain - job status using a single measure of exposure. Failure to take into account the frequency and duration may lead to the misclassification of the exposure and increase the risk of underestimation of the effects. Third, it was not possible to examine the incidence (rather than prevalence) of hypertension according to retirement due to lack of information on the date of diagnosis. However, excluding initial cases of hypertension allowed examining partially the incidence. Fourth, despite we adjusted for several potential confounders, there is the possibility of confounding by unmeasured factors. Mental health factors, such as depression, were not measured. Depression can increase the risk of retirement (38) and decrease blood pressure (39). In such a context, if retirement has a beneficial effect on hypertension (22), depression may lead to positive confounding bias likely to underestimate the true association job status-hypertension. Moreover, we cannot exclude the probability of residual confounding due to measurement errors of potential confounders included in the models.

The HWSE generally varies from one cohort to another (10). The assessment of the HWSE should precede any study of the relationship between occupational exposures and health to guide the choice of appropriate statistical methods. We observed the HWSE in both genders, especially in younger men and older women. G-estimation would be appropriate for controlling the HWSE bias in our data given its effectiveness in the absence of positivity, unlike the inverse probability weighting. In addition, g-estimation requires less modeling compared to g-formula (2, 7). The effect of job strain on hypertension is inconsistent (40). Inadequate control of the HWSE may contribute to explain such an inconsistency.

Contributors

VKM, DT and CB had the initial idea for this study. VKM conducted data analyses, interpreted results and wrote and revised the manuscript. DT supervised analytical approach, interpretation of results and reviewed and revised the manuscript. AM supervised the aspects of the study related to blood pressure measurement and interpretation and reviewed and revised the manuscript. XT and NP reviewed and revised the manuscript. CB supervised all aspects of the study and reviewed and revised the manuscript.

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Competing interests

None declared.

Ethics approval

The Comité d'éthique de la recherche (CÉR) du CHU de Québec-Université Laval approved this study.

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FIGURES

Figure 1. Causal diagram representing the healthy worker survivor effect (adapted from Garcia et al., 2017)