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**Job strain and atrial fibrillation
- Results from the Swedish Longitudinal Occupational Survey of Health and
meta-analysis of three studies**

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The work presented in the article has not been presented elsewhere.

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Abstract

Background: Knowledge about the impact of occupational exposures, such as work stress, on the risk of atrial fibrillation is limited. The present study aims to investigate the association between job strain, a measure of work stress, and atrial fibrillation.

Design: Prospective cohort study design and fixed-effect meta-analysis.

Methods: Data from the Swedish Longitudinal Occupational Survey of Health (SLOSH) was utilised for the main analysis, combining self-reported data on work stress at baseline with follow-up data on atrial fibrillation from nationwide registers. Cox proportional hazard regression analyses were used to estimate hazard ratios (HR) and 95% confidence intervals (95% CI). A fixed-effect meta-analysis was conducted to pool the results from the present study with results from two similar previously published studies.

Results: Based on SLOSH data, job strain was associated with an almost 50% increased risk of atrial fibrillation (HR 1.48, 95% CI 1.00-2.18) after adjustment for age, sex and education. Further adjustment for smoking, physical activity, body mass index and hypertension did not alter the estimated risk. The meta-analysis of the present and two previously published studies showed a consistent pattern, with job strain being associated with increased risk of AF in all three studies. The estimated pooled HR was 1.37 (95% CI 1.13-1.67).

Conclusions: The results highlight that occupational exposures, such as work stress, may be important risk factors for incident atrial fibrillation.

Abstract word count: 224

Keywords

Atrial fibrillation; Work; Stress, psychological; Risk factors; Cohort study

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Introduction

Atrial fibrillation (AF) is the most common type of cardiac arrhythmia and is associated with severe consequences such as a 2 to 5-fold increased risk of stroke and premature mortality.¹⁻³ In a European perspective, it is estimated that approximately 10 million people currently suffer from atrial fibrillation, with 100,000-200,000 new-onset cases every year.² The incidence of AF has increased during recent decades, and with an ageing population, this trend is expected to continue.⁴

Even though AF is prevalent in the population and should be viewed as a major public health concern, there is limited knowledge about the underlying risk factors and biological mechanisms of the disease. Except for high age and male sex, other heart diseases and hypertension have been associated with increased risk of AF, as well as smoking, heavy alcohol consumption, obesity, sleep apnea and prolonged physical exertion.⁵⁻⁷ More research on risk factors for AF and underlying mechanisms for the disease has been called for.¹

It has been observed that occupational exposures, such as noise, night work, long working hours, and work-related psychosocial factors, including work stress, are associated with coronary heart disease and stroke.⁸⁻¹¹ However, few studies have been undertaken to explore occupational exposures in relation to AF risk,¹²⁻¹⁴ and to our knowledge, only two studies have previously been published regarding work stress and AF.^{15, 16}

The most frequently used model for research on work stress is the demand-control model, which postulates that a job characterised by high psychological demands in

combination with low control over the work situation (job strain) implies an increased risk of ill-health.^{17,18}

The aim of the present study was to investigate the association between work stress, defined as job strain, and incident atrial fibrillation in a representative sample of the Swedish working population. A further aim was to pool the results from the present study with available data from two previously published studies on the same topic.

Methods

The Swedish Longitudinal Occupational Survey of Health

In the present study, data from the Swedish Longitudinal Occupational Survey of Health (SLOSH) was utilised.¹⁹ The overall aim of SLOSH is to increase the understanding of the complex associations between labour force participation, work organisation, work environment and health. The study population is drawn from the Swedish Work Environment Survey, aiming to cover a representative sample of the working population in Sweden. The first SLOSH follow-up of these participants was carried out in 2006, with subsequent data collections every second year over the period 2008-2016. In each data collection wave after 2006, previous participants were re-invited. New participants have been added successively to the study population.

The surveys consist of postal self-completion questionnaires covering a broad range of topics, including socio-demographic characteristics, work-related factors, lifestyle and health. Registry data from national registries covering inpatient and outpatient hospital care, as well as cause-specific mortality, is also available. The response rate was 65% in 2006, 61% in 2008, and 57% in 2010.

SLOSH has been approved by the Regional Ethical Review Board in Stockholm, and all participants gave informed consent to participate in the study.

Analytical sample

For this study, we used data from participants included for the first time in SLOSH 2006, 2008 or 2010, who were gainfully employed and worked at least 30% (n=13,477).

Participants with a history of atrial fibrillation, myocardial infarction or heart failure prior to inclusion in the study (n=201), or for whom information on job strain at baseline was missing (n=76) were excluded, leaving 13,200 participants (5,980 men and 7,220 women) as our analytical sample.

Work stress according to the job demand-control (job strain) model

Work stress was measured at baseline (i.e. the time of study inclusion) and was defined as job strain according to the job demand-control model. The Swedish demand-control questionnaire with five job demand items and six control items was used to measure job demands and control.²⁰ Mean response scores for job demands and control, respectively, were calculated for each participant. The median scores for job demands and control for the total study population were used as cut-points, defining high demands as demand scores strictly above the median, and low control as control scores strictly below the median.

In the main analyses, those with job strain (high demands and low control) were compared with all others. We also constructed four categories based on the combinations of job demands and control: low strain jobs (low demands, high control); passive jobs (low demands, low control); active jobs (high demands, high control); and high strain jobs (high demands, low control).

Atrial fibrillation

Incident cases of atrial fibrillation, and flutter were identified through the Swedish national inpatient, outpatient and mortality registers using ICD-10 code I48.

Potential confounders

Several socio-demographic, lifestyle and health-related factors have previously been observed to be associated with both job strain and atrial fibrillation, and could thus potentially act as confounders when studying the association between job strain and atrial fibrillation. In the analyses, the following factors were considered to be potential confounders: Age in years (continuous), sex (man/woman), education (compulsory school; 2-years upper secondary school; 3 or 4 years upper secondary school; university education <3 years; university education ≥ 3 years), smoking (daily; occasional; no), leisure-time physical activity (never or seldom; every now and then; regularly), body mass index (≤ 24.99 kg/m²; 25.00-29.99 kg/m²; ≥ 30.00 kg/m²), and self-reported hypertension (yes; no).

Studies included in meta-analysis

To our knowledge, only two studies have previously been published presenting results on the association between job strain and atrial fibrillation, briefly described below.

The Primary Prevention Study (PPS)

PPS is a population-based cohort study conducted in Gothenburg, Sweden.¹⁵ The study includes men born between 1915 and 1925, with study baseline 1974-1977. The analyses comprised 6,035 men, with an average follow-up time of 16.8 years. Job strain was

measured by using a job-exposure matrix based on occupation at baseline. During follow-up, 436 atrial fibrillation cases were identified by linkage to national registers.

The Work, Lipids and Fibrinogen Study (WOLF)

The WOLF study is a longitudinal occupational cohort study conducted in Sweden.¹⁶ The baseline examination was carried out 1992-1998, and the analyses comprised 10,121 men and women, with a median follow-up time of 13.6 years. Job strain was measured by the Swedish Demand-Control questionnaire. In total, 253 atrial fibrillation cases were identified during follow-up using national registers.

Statistical analyses

All participants were followed from the time of inclusion in SLOSH to their first recorded AF event, death or end of study follow-up (31 December 2013), whichever came first. Kaplan-Meier curves were used to illustrate the hazard function for incident atrial fibrillation during follow-up by job strain category. Cox proportional hazard regression analyses were used to estimate hazard ratios (HR) and 95% confidence intervals (CI) to evaluate the association between job strain and risk of incident atrial fibrillation. The assumption of proportional hazard over time was checked by inspecting the plot for the hazard function, and by including an interaction term between job strain and follow-up time in the Cox hazard regression model. Potential difference in the association between job strain and AF by sex was analysed by stratified analyses and by including an interaction term between sex and job strain in the Cox hazard regression model. All analyses were conducted using SPSS version 21.

In addition to analyses of original SLOSH data, we also performed a meta-analysis in which we pooled the estimated HR from the present study with the results from the two

previously published studies on the same topic. We pooled the study-specific HR estimates in a fixed-effect meta-analysis, using R version 3.4.2. Weights for the included studies were derived by the inverse variance method. Heterogeneity between studies was evaluated using the I^2 statistic.

Results

During a total follow-up time of 79,738 person-years (median follow-up time 5.7 years), 145 incident cases of atrial fibrillation (94 men and 51 women) were identified using national registers. The background characteristics of the study population are shown in table 1. The mean age was 47.4 years at baseline, and 54.7 percent of the study population were women. Those categorised as being exposed to job strain were on average slightly younger (46.9 vs 47.5 years), more often female, had shorter education, were smokers, exercised less often and reported a higher frequency of hypertension, compared with those who were not exposed to job strain (Table 1).

The plotted hazard function showed a higher risk of atrial fibrillation for those exposed to job strain as compared to all others (Figure 1). No obvious violation of the proportional hazard assumption was observed when inspecting the plot, which was also confirmed when including a job strain*time interaction term in the Cox proportional hazard regression model.

In the Cox regression model adjusted for age, sex and education, job strain was associated with an approximately 50% higher risk of atrial fibrillation (HR 1.48, 95% CI 1.00-2.18). Further adjustment for smoking, leisure-time physical activity, body mass index and hypertension did not alter the estimated HR in any major way, but as expected, the confidence intervals became slightly wider when more variables were included in the

model (Table 2). When analysing the four different groups based on the combinations of job demands and control, using the low strain group as reference, the estimated HRs for the high strain group were similar to those observed for the job strain group when only two exposure groups were used (Table 2). Both the passive and active groups had estimated hazard ratios close to the low strain group.

When stratifying the analyses by sex, the association between job strain and AF was only observed in men (HR 1.79, 95% CI 1.10-2.90 for men; HR 1.02, 95% CI 0.53-1.96 for women, adjusted for age and education). However, no statistically significant effect modification was found when evaluated by including an interaction term sex*job strain in the model (p=0.26).

When pooling the results from the present study with two previously-published studies in a fixed effect meta-analysis, job strain was associated with a 37% increased risk of atrial fibrillation (HR 1.37, 95% CI 1.13-1.67), with a consistent pattern across studies. The I^2 statistic indicated that there was no heterogeneity between studies ($I^2=0\%$).

Discussion

In the present study, we found that job strain was associated with an almost 50% increased risk of incident atrial fibrillation in the general working population in Sweden. The results were consistent with two previously published studies, and when pooling the results from all three studies, job strain was associated with a 37% higher risk of AF.

The present study is one of few where occupational factors have been investigated in relation to atrial fibrillation,¹²⁻¹⁴ with only two previously focusing on work stress.^{15, 16} In accordance with the results from the present study, long working hours, which could be seen as an indicator of work-related stress, has also been found to be associated with

increased AF risk,¹³ further strengthening the idea that occupational stress is associated with AF. However, in studies using more general measures of stress, the results have been mixed.²¹⁻²³

The biological mechanisms linking work stress to AF are not fully known. However, reactions to stress include physiological responses involving both the hypothalamic-pituitary-adrenal axis and the autonomous nervous system, leading to increased release of glucocorticoid hormones, such as cortisol, and increased sympathetic activity.^{24,25} In line with this, chronic stress has been associated with low-grade inflammatory state and elevated blood pressure.²⁵⁻²⁸ Both inflammation and hypertension may in turn contribute to atrial fibrosis and structural remodelling of the atrium.²⁹ Furthermore, mental stress has been observed to be associated with altered left atrial electrophysiology.³⁰ Autonomic imbalance, neurohormonal activation, altered left atrial electrophysiology, and structural remodelling of the atrium, have all been proposed to play important roles in the development of AF,^{29,31} making a biological pathway between work stress and atrial fibrillation plausible.

The current study has several strengths. The SLOSH study has a prospective design, and is based on a large sample from the general working population in Sweden, including both men and women. An established and validated operationalisation of work stress, job strain, was used, which has frequently been used in research on work stress and cardiovascular outcomes.^{9,10} Furthermore, national registers of high quality^{32,33} were used to identify incident atrial fibrillation cases.

All three studies included in the meta-analysis in the present study used the same concept of work stress, i.e. job strain based on the demand-control model, had a prospective cohort study design, and the outcome was identified by means of national registers,

improving the comparability between studies and making the pooling of the results highly relevant. However, it should be noted that the PPS study used a job-exposure matrix to measure job strain, while the demand-control questionnaire was used in the WOLF and SLOSH studies. By that, slightly different dimensions of the work conditions may have been captured in PPS as compared with the other two studies. Still, the estimated effect sizes were similar across the three studies.

Some limitations should also be considered. Even if the sampling procedure in SLOSH was aimed at generating a representative sample of the working population in Sweden, the participation rate has declined over more recent data collection waves. The study population can still be viewed as broadly representative, but lower participating rates have been observed for those who were younger, male, had less education and were born outside Scandinavia.

Atrial fibrillation as a disease is known to develop over several years, and the disease can remain “silent” and undiagnosed by the health care system for a long time. We used high quality registers to identify incident AF, but we cannot preclude the possibility that some cases were not identified in our study. However, this potential misclassification of the outcome is likely to be non-differential in relation to exposure and is thus likely to yield an attenuated hazard ratio, if any effect.

Other clinical conditions, including hyperthyroidism and cardiac valvulopathy, are known to be associated with incidence of AF. If these conditions are present at baseline and are associated with increased likelihood of rating the work situation as stressful, the observed hazard ratios might have been slightly overestimated. However, we do not think this potential bias is likely to explain all of association between job strain and AF observed in this study.

We found only two previously published articles on the same topic, both showing associations between job strain and AF in the same direction as those found in the SLOSH study. When doing meta-analysis including published studies, the potential effect of publication bias, i.e. that studies showing negative results are less likely to be published, should always be considered. Furthermore, in the meta-analysis, all three studies were based on Swedish samples, and studies from other countries and different regions of the world are needed. Other measures or indicators of work stress, for example effort-reward imbalance and job insecurity should also be analysed in relation to AF risk in order to get a more comprehensive understanding of the role of work stress as a potential risk factor for AF. In addition, as the results in the present study are based on observational data, the ability to draw conclusion about causation is limited.

In conclusion, our study adds further support to the hypothesis that occupational factors such as work stress, may be associated with increased risk of AF.

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Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest.

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Author contributions

EF contributed to the conception and design of the work, data analysis, interpretation of data and drafted the manuscript. LLMH and HW contributed to the acquisition and interpretation of data and critically revised the manuscript. MN contributed with interpretation of data and critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of work, ensuring integrity and accuracy.

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Table 1. Background characteristics of the study population. The Swedish Longitudinal Occupational Survey of Health (SLOSH), inclusion years 2006, 2008 and 2010.

	Total study population, n=13,200	No strain, n=10,592	Job strain, n=2608	P-value*
Gender, n (%)				
Men	5,980 (45.3)	4,957 (46.8)	1,023 (39.2)	<0.001
Women	7,220 (54.7)	5,635 (53.2)	1,585 (60.8)	
Age, mean (sd)	47.4 (10.8)	47.5 (10.8)	46.9 (10.9)	0.022
Atrial fibrillation, n (%)				
No	13,055 (98.9)	10,481 (99.0)	2,574 (98.7)	0.262
Yes	145 (1.1)	111 (1.0)	34 (1.3)	
Education, n (%)				
Compulsory school	2,044 (15.5)	1,534 (14.5)	510 (19.6)	<0.001
2 years upper secondary school	2,928 (22.3)	2241 (21.2)	687 (26.5)	
3 or 4 years upper secondary school	2,959 (22.5)	2,322 (22.0)	637 (24.5)	
University education shorter than 3 years	1,857 (14.1)	1,525 (14.5)	332 (12.8)	
University education 3 years or longer	3,359 (25.5)	2,928 (27.8)	431 (16.6)	
Smoking, n (%)				
Daily	1,471 (11.2)	1,079 (10.3)	392 (15.1)	<0.001
Occasional	607 (4.6)	468 (4.5)	139 (5.4)	

	No	11,016 (84.1)	8,956 (85.3)	2,060 (79.5)	
Exercise, n (%)					
	Never or seldom	2,597 (19.9)	2,007 (19.2)	590 (22.8)	<0.001
	Every now and then	4,575 (35.0)	3,654 (34.9)	921 (35.6)	
	Regularly	5,892 (45.1)	4,815 (46.0)	1,077 (41.6)	
Body Mass Index, n (%)					
	≤24.99	6,561 (51.0)	5,294 (51.3)	1,267 (50.0)	0.023
	25.0-29.99	4,878 (37.9)	3,927 (38.1)	951 (37.5)	
	≥30.0	1,416 (11.0)	1,098 (10.6)	318 (12.5)	
Hypertension, n (%)					
	No	10,915 (84.0)	8,823 (84.6)	2,092 (81.6)	<0.001
	Yes	2,083 (16.0)	1,610 (15.4)	473 (18.4)	

*P-values derived from Chi-square tests for categorical variables and t-test for continuous variable.

Table 2. The association between job strain and risk of incident atrial fibrillation. Hazard Ratios (HR) with 95% confidence intervals (95% CI). The Swedish Longitudinal Occupational Survey of Health (SLOSH), inclusion years 2006, 2008 and 2010, end of follow-up 31 December 2013.

	HR (95% CI) ^a	HR (95% CI) ^b	HR (95% CI) ^c	HR (95% CI) ^d
	N=13,200	N=13,147	N=12,993	N=12,589
	AF events=145	AF events=142	AF events=142	AF events=134
No strain	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Job strain	1.25 (0.85-1.83)	1.48 (1.00-2.18)	1.47 (0.99-2.17)	1.46 (0.98-2.18)
Low strain	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Passive	0.85 (0.53-1.34)	1.01 (0.63-1.61)	0.98 (0.61-1.56)	1.03 (0.63-1.67)
Active	0.92 (0.59-1.43)	0.97 (0.62-1.53)	0.95 (0.60-1.50)	0.96 (0.60-1.54)
High strain	1.15 (0.73-1.81)	1.47 (0.93-2.32)	1.44 (0.91-2.28)	1.46 (0.91-2.34)

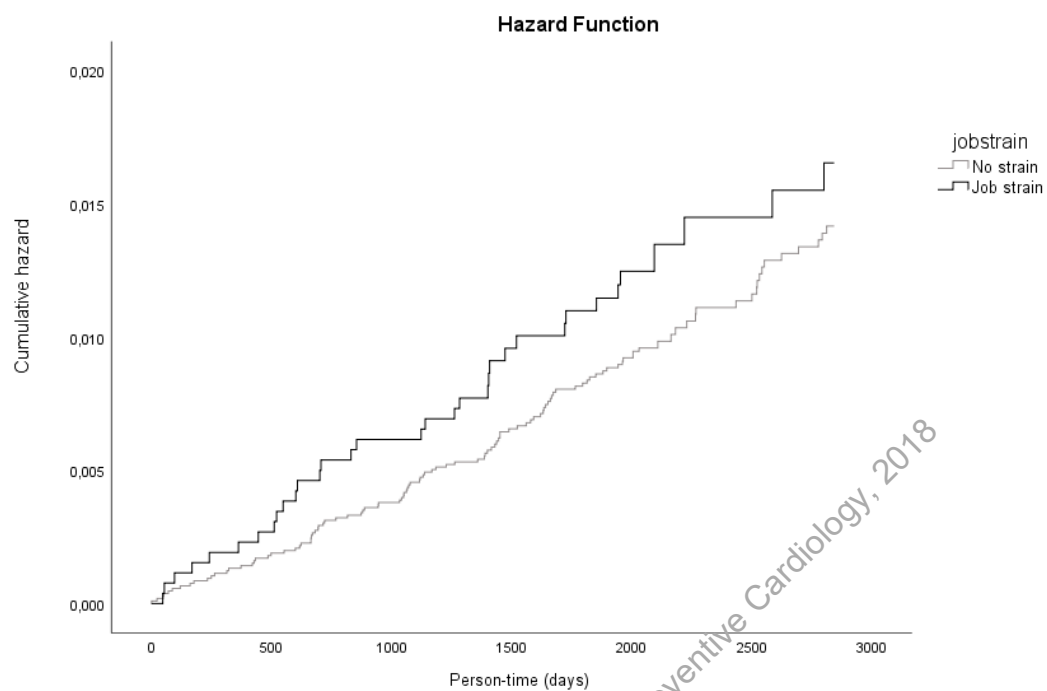
^a Crude, unadjusted model

^b Adjusted for age, sex, and education

^c Adjusted for age, sex, education, smoking, and physical activity

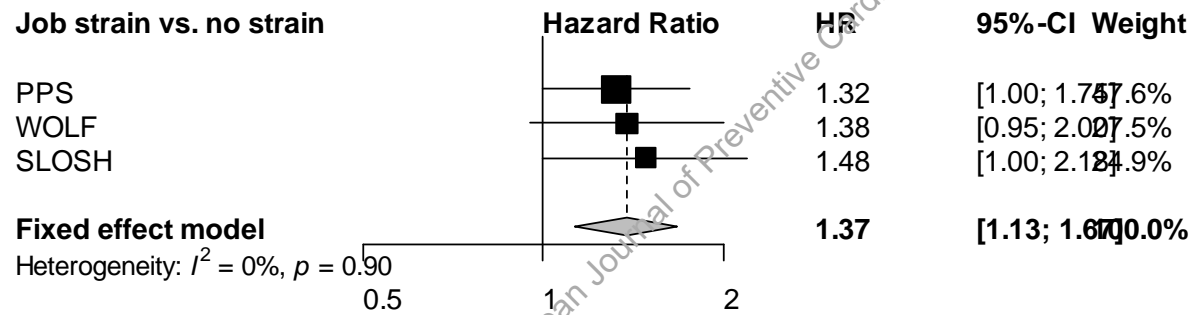
^d Adjusted for age, sex, education, smoking, physical activity, Body Mass Index, and hypertension

Figure 1.



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Figure 2.



PPS -The Primary Prevention Study¹⁵

WOLF -The Work, Lipids and Fibrinogen Study¹⁶

SLOSH -The Swedish Longitudinal Occupational Survey of Health

Figure Legends

Figure 1. The hazard function for incident atrial fibrillation, the job strain vs. no strain group. The Swedish Longitudinal Occupational Survey of Health (SLOSH), inclusion years 2006, 2008, or 2010, end of follow-up 31 December 2013.

Figure 2. Study-specific estimates and pooled estimate for three studies on the association between job strain vs. no strain and the risk of atrial fibrillation.

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