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Long Working Hours and Risk of Recurrent Coronary Events

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ABSTRACT

BACKGROUND Evidence from prospective studies has suggested that long working hours are associated with incident coronary heart disease (CHD) events. However, no previous study has examined whether long working hours are associated with an increased risk of recurrent CHD events among patients returning to work after a first myocardial infarction (MI).

OBJECTIVES The purpose of this study was to examine the effect of long working hours on the risk of recurrent CHD events.

METHODS This is a prospective cohort study of 967 men and women age 35 to 59 years who returned to work after a first MI. Patients were recruited from 30 hospitals across the province of Quebec, Canada. The mean follow-up duration was 5.9 years. Long working hours were assessed on average 6 weeks after their return to work. Incident CHD events (fatal or nonfatal MI and unstable angina) occurring during follow-up were determined using patients' medical files. Hazard ratios were estimated using Cox proportional hazard regression models. Splines and fractional polynomial regressions were used for flexible exposure and time modeling.

RESULTS Recurrent CHD events occurred among 205 patients. Participants working long hours (≥55 h/week) had a higher risk of recurrent CHD events after controlling for sociodemographics, lifestyle-related risk factors, clinical risk factors, work environment factors, and personality factors (hazard ratio vs. 35 to 40 h/week: 1.67; 95% confidence interval: 1.10 to 2.53). These results showed a linear risk increase after 40 h/week and a stronger effect after the first 4 years of follow-up and when long working hours are combined with job strain.

CONCLUSIONS Among patients returning to work after a first MI, longer working hours per week is associated with an increased risk of recurrent CHD events. Secondary prevention interventions aiming to reduce the number of working hours among these patients may lower the risk of CHD recurrence. (J Am Coll Cardiol 2021;77:1616–25) © 2021 by the American College of Cardiology Foundation.

Cardiovascular disease (CVD) is the leading cause of death worldwide (1). The identification of new preventive measures is a priority to reduce the burden of these diseases. In this regard, it is now recognized that certain characteristics of the work environment could have an adverse effect on cardiovascular health (2).

Long working hours are frequent. According to the International Labour Office, approximately 1 in 5 workers worldwide work over 48 h/week, representing more than 614 million people (3). American and European population data also suggest a high prevalence of long working hours, with 19% of Americans and 15% of Europeans working more than 48 h in 2010 and 2015, respectively (4,5). Previous prospective studies have documented the deleterious effect of long working hours on cardiovascular health (6). A recent systematic review suggests that long working hours are associated with the incidence of coronary heart disease (CHD) and stroke (7).

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The effect of long working hours on CVD incidence may be higher in patients with pre-existing cardiovascular conditions. In support of this hypothesis, a recent study suggests that the adverse effect of certain work stressors on mortality is of a greater magnitude among participants who already have a cardiometabolic disease (8). However, to our knowledge, no previous study has examined the effect of long working hours on the risk of recurrent CVD events among patients who have had a first CVD event. The objective of the present study was to examine the effect of long working hours on the risk of recurrent CHD among patients returning to work after a first myocardial infarction (MI).

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METHODS

STUDY DESIGN AND POPULATION. The study design was reported in detail elsewhere (9). Briefly, a total of 1,191 patients, age <60 years were recruited from 30 hospitals in the province of Quebec, Canada, between November 1995 and October 1997. To be included in the study, participants had to: 1) have a history of initial acute MI; 2) be younger than 60 years of age; 3) hold a paid job in the 12 months prior to their MI; and 4) plan to return to work at least 10 h/week within 18 months after their MI. A total of 972 patients agreed to participate. After excluding 4 participants with missing data on covariates and 1 participant with missing data on worked hours, the final study population included 967 patients. The study was approved by the ethics board of each hospital and by the ethical review board of the CHU de Québec-Université Laval research center (F9-52293). Written informed consent from each patient was obtained before hospital discharge.

DATA COLLECTION. Information on the initial acute MI and on past medical history was documented at first hospitalization. Telephone interviews were performed at baseline (on average, 6 weeks after return to work), then after 2 and 6 years subsequently. The mean follow-up was 5.9 years. Baseline data collection included information on demographics, hospital readmissions, coronary heart disease risk factors, physical and chemical exposures at work, psychosocial factors inside and outside of work, and personality factors. Follow-up interviews were used to collect information on hospital readmissions. Information on hospital readmissions for each patient was verified by retrieving medical records throughout hospitals in Canada and abroad. Information on all recurrent CHD events was obtained using 2 reliable and validated sources: the hospital summary database for Quebec residents (MED-ECHO) (10,11) and the Quebec Institute of Statistics (12,13), with an agreement of 98.8% for MI events.

ABBREVIATIONS AND ACRONYMS

CHD = coronary heart disease
CVD = cardiovascular disease
HR = hazard ratio
MI = myocardial infarction

LONG WORKING HOURS. Total weekly hours were obtained summing the number of hours worked in the main occupation with hours worked in a different occupation. Total weekly worked hours were categorized as part-time (21 to 34 h/week), full-time (35 to 40 h/week), low overtime (41 to 54 h/week), and medium/high overtime (≥55 h/week) (7,14).

CORONARY HEART DISEASES. The outcome was the first recurrent CHD event among a composite of fatal CHD, nonfatal MI, and unstable angina (15). A cardiologist and a vascular specialist (A.M.), who were blind to the patients' characteristics, adjudicated the first MI and each subsequent cardiovascular event. An MI diagnosis required an increase in cardiac enzymes with 1 of the following symptoms: ischemic chest pain, evolutionary ST-T segment changes, or new Q waves (16). The unstable angina diagnosis required hospitalization due to prolonged chest discomfort attributed to angina with either ischemic electrocardiographic changes or urgent coronary revascularization within 14 days of symptom onset. Causes of death were ascertained with hospital charts, next-of-kin interviews, autopsy result, and death certificates. CHD deaths were defined by the International Classification of Diseases-9th Revision codes 410 to 414 as underlying causes of death.

COVARIATES. The following categories of variables were included as potential confounders:

- *Sociodemographic factors*: sex, age, marital status, education, and perceived economic situation.
- *Clinical prognostic factors*: number of prior comorbid conditions (stroke, angina, coronary revascularization, chronic pulmonary disease); thrombolysis; number of in-hospital events during the first MI (reinfarction, recurrent angina, congestive heart failure, cardiac arrest, and coronary revascularization); and number of recommended medications after discharge.
- *CHD risk factors:* hypertension, dyslipidemia (treated or noted in medical record or diagnosed after first MI), diabetes mellitus, and family members experiencing CHD younger than 60 years.
- *Lifestyle-related factors:* alcohol consumption, smoking status, body mass index, and physical activity performed within the last 2 weeks

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TABLE 1 Description of the Study Population at Baseline by Weekly Working Hours

	Weekly Working Hours			
	<35	35-40	41-54	≥55
Sex				
Men	157 (18.2)	418 (48.4)	197 (22.8)	92 (10.7)
Women	38 (36.9)	56 (54.4)	7 (6.8)	2 (1.9)
Age, yrs				
≤39	23 (22.8)	42 (41.6)	22 (21.8)	14 (13.9)
40-49	73 (16.5)	224 (50.7)	101 (22.9)	44 (10.0)
50-59	99 (23.4)	208 (49.1)	81 (19.1)	36 (8.5)
Marital status				
Married/common law partner	160 (19.9)	388 (48.1)	179 (22.2)	79 (9.8)
Divorced/separated/widowed/single	35 (21.7)	86 (53.4)	25 (15.5)	15 (9.3)
Perceived economic situation				
Financially comfortable	46 (21.1)	84 (38.7)	58 (26.7)	29 (16.4)
Adequate income	127 (20.0)	336 (52.6)	121 (18.9)	55 (8.6)
Poor	22 (19.9)	54 (48.7)	25 (22.5)	10 (9.0)
Education				
College/university	96 (22.9)	195 (46.4)	91 (21.7)	38 (9.1)
Primary/high school	99 (18.1)	279 (51.0)	113 (20.6)	56 (10.2)
Hypertension				
No	151 (20.8)	348 (48.3)	153 (21.3)	69 (9.6)
Treated	31 (18.9)	96 (58.5)	25 (15.2)	12 (7.3)
Untreated	14 (16.9)	30 (36.1)	26 (31.3)	13 (15.7)
Dyslipidemia				
No	74 (22.2)	159 (47.8)	70 (21.0)	30 (9.0)
Yes	121 (19.1)	315 (50.0)	134 (21.1)	64 (10.1)
Diabetes				
No	169 (20.1)	415 (49.4)	178 (21.2)	78 (9.3)
Yes	26 (20.5)	59 (46.5)	26 (20.5)	16 (12.6)
Smoking status				
Nonsmoker	25 (24.5)	49 (48.0)	20 (19.6)	8 (7.8)
Ex-smoker	120 (20.1)	296 (49.5)	124 (20.7)	58 (9.7)
Current smoker	50 (18.7)	129 (48.3)	60 (22.5)	8 (7.8)
Family history of CHD				
No	100 (21.3)	222 (47.2)	106 (22.6)	42 (8.9)
Yes	95 (19.1)	252 (50.7)	98 (19.7)	52 (10.5)
Body mass index				
Normal/overweight	154 (19.8)	381 (49.0)	167 (21.5)	75 (9.7)
Obese	41 (21.6)	93 (49.0)	37 (19.5)	19 (10.0)
Alcohol consumption per week				
0	79 (21.8)	183 (50.4)	65 (17.9)	36 (38.3)
1-10	100 (21.2)	228 (48.4)	102 (21.7)	41 (43.6)
Over 10	16 (12.0)	63 (47.4)	37 (27.8)	17 (12.8)
Physical activity per week				
Vigorous	88 (22.3)	189 (47.9)	88 (22.3)	30 (7.6)
Moderate	81 (20.3)	196 (49.0)	88 (22.0)	35 (8.8)
Inactivity	26 (15.1)	89 (51.7)	28 (16.3)	29 (16.9)
Prior comorbid conditions				
0	159 (20.3)	385 (49.1)	170 (21.7)	70 (8.9)
1+	36 (19.7)	89 (48.6)	34 (18.6)	24 (13.1)
Admission blood pressure, mm Hg				
Systolic	138.6 ± 30.9	137.8 ± 25.8	140.4 ± 25.9	142.2 ± 25.5
Diastolic	83.5 ± 19.4	83.5 ± 16.4	86.1 ± 15.9	86.3 ± 16.5
Thrombolysis				
No	80 (18.1)	210 (47.6)	108 (24.5)	43 (9.8)
Yes	115 (21.9)	264 (50.2)	96 (18.3)	51 (9.7)

Continued on the next page

evaluated in metabolic equivalent tasks (METs)-h/week (0 for inactivity, 0.25 to 14.08 for moderate, and >14.08 for vigorous exercise) (17).

- *Work environment characteristics:* Job strain, a combination of high psychological demands and low decision latitude at work was measured using 18 items from the Job Content Questionnaire (18). Psychological demands (9 items) reflect quantity of work, time constraints, and level of intellectual effort required. Decision latitude (9 items) reflects opportunities for learning, autonomy, and participation in the decision-making process. The psychometric properties of the original whole Job Content Questionnaire scale of 18 items (19,20) and its French (20–23) version have been previously demonstrated. Workers with psychological demand scores of 24 or higher (the median for the general Quebec working population) were classified as having high psychological demands (24). Workers with decision latitude scores of 72 or lower (median of general Quebec working population) were classified as having low decision latitude (24). Job strain exposure was defined as high psychological demands and low decision latitude. Other work environment characteristics included social support at work assessed using 4 subscales of supervisor and coworker support and conflict from the validated Work Interpersonal Relationship Inventory (25). Workers without a supervisor (n = 178, 18.3%) were imputed twice the score of coworker support. We used dummy indicators for those with missing information on social support at work, the sole variable with missing information for more than 5% of the participants (n = 54, 5.6%). The number of physical and chemical exposures at work (passive smoking, chemicals, pollution, noise, excessive heat, excessive cold, and physical exertion at work) were also measured.
- *Other factors:* social support outside work (low >0, high = 0; range 0 to 11), using an 11-item subscale of the validated 19-item MOS (Medical Outcomes Study) Social Support Survey (26); 3 personality factors with their scores split at the median (alexithymia [27], hostile affect [28], and suppressed anger [29]); and psychological distress (dichotomized at the highest quintile observed in the general population) (30).

STATISTICAL ANALYSES. Cox proportional hazards models were used. Person-years of follow-up were calculated from the baseline interview until the first of the following events: recurrent CHD, death, or the end of the follow-up, whichever event came first.

Nonrespondents at either follow-up (n = 30) were considered dropouts and were censored at the midpoint of the interval between their last data collection and the subsequent follow-up. Survival curves were obtained by the Kaplan-Meier method with log-rank test for comparison, and unadjusted rates of recurrent CHD per 100 person-years were computed. Cox regression models were used to estimate hazard ratios (HRs) of recurrent CHD and their 95% confidence intervals (CIs). Cox regression models were sequentially adjusted for each subgroup of cofactors to assess a possible overadjustment by intermediate factors. We examined the effect modification by job strain using a multicategorical variable combining exposure to job strain and to long working hours. Spline regression models were used to estimate the effect of weekly working hours, in its continuous form, on the risk of recurrent CHD events. Fractional polynomial regressions were used for flexible time modeling and to examine different exposure-risk windows (31). Sensitivity analyses were conducted using the Fine and Gray method, considering noncardiovascular deaths (n = 19) as competing risks. These analyses yielded similar estimates (Supplemental Table 1). Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

TABLE 1 Continued

	Weekly Working Hours			
	<35	35-40	41-54	≥55
Number of in-hospital events during first MI				
0	118 (21.2)	263 (47.1)	125 (22.4)	52 (9.3)
1+	77 (18.8)	211 (51.6)	79 (19.3)	42 (10.3)
Number of discharge medication				
0	3 (18.8)	3 (18.8)	6 (37.5)	4 (25.0)
1	27 (22.3)	63 (52.1)	24 (19.8)	7 (5.8)
2	70 (17.8)	202 (51.4)	83 (21.1)	38 (9.7)
3+	95 (21.7)	206 (47.1)	91 (20.8)	45 (10.3)
Physical and chemical factors				
0	50 (24.0)	109 (52.4)	36 (17.3)	13 (6.3)
1	47 (25.5)	81 (44.0)	35 (19.0)	21 (11.4)
2	30 (15.0)	102 (51.0)	47 (23.5)	21 (10.5)
3+	68 (18.1)	182 (48.5)	86 (22.9)	39 (10.4)
Social support at work				
High	86 (20.9)	198 (48.2)	89 (21.7)	38 (9.3)
Low	97 (19.3)	254 (50.6)	106 (21.1)	45 (9.0)
Job strain				
No	160 (20.9)	372 (48.6)	162 (21.2)	72 (9.4)
Yes	35 (17.4)	102 (50.8)	42 (20.9)	22 (11.0)
Social support outside work				
High	154 (20.4)	366 (48.5)	165 (21.9)	70 (9.3)
Low	41 (19.3)	108 (50.9)	39 (18.4)	24 (11.3)
Psychological distress				
No	123 (18.6)	328 (49.6)	154 (23.3)	57 (8.6)
Yes	72 (23.6)	146 (47.9)	50 (16.4)	37 (12.1)

Values are n (%) or mean ± SD.
CHD = coronary heart disease; MI = myocardial infarction.

RESULTS

During the study period, 205 participants had a recurrent CHD event (21.2%). The overall incidence rate was 3.60 cases per 100 person-years. **Table 1** presents characteristics of the participants at baseline, according to weekly working hours categories. Men were over-represented in the highest category of working hours, that is, among those working 55 h/week and above (10.7% of all men vs. 1.9% of all women, respectively). Workers of younger age, who perceived their economic situation as financially comfortable, were also proportionally over-represented in the highest working hours category. Several CHD risk factors (hypertension, diabetes), lifestyle habits (smoking status, alcohol intake, physical inactivity) and work environment (job strain, low support) risk factors were also more frequent in this category. Finally, participants in the highest category of weekly working hours represented 12.4% of those with high psychological distress and 8.6% of participants without.

The descriptive Kaplan-Meier curve depicted in **Central Illustration A** shows that workers exposed to long working hours had a higher risk of recurrent CHD events. **Table 2** presents the association between long working hours and recurrent CHD in sequentially adjusted models. In the unadjusted analysis, long working hours (≥ 55 h/week vs. 35 to 40 h/week) were associated with a 2-fold increase in the risk of recurrent CHD (HR: 2.00; 95% CI: 1.36 to 2.95). Long working hours remained associated with the risk of recurrent CHD (HR: 1.67; 95% CI: 1.10 to 2.53) in the fully adjusted model, controlling for sociodemographics, lifestyle-related risk factors, clinical risk factors, work environment characteristics, and personality factors (**Central Illustration B**). **Table 3** presents the association between long working hours and recurrent CHD events according to job strain exposure. Participants working ≥55 h/week that were simultaneously exposed to job strain had the highest risk when compared with workers working 35 to 40 h/week and not exposed to job strain, although the estimate was imprecise (HR: 2.55; 95% CI: 1.30 to 4.98). The p value for the multiplicative interaction term between long working hours and job strain was $p = 0.18$.

Figure 1 presents results from the spline regression model and shows a constant risk increase after the reference level of 40 h/week. The fully adjusted HRs

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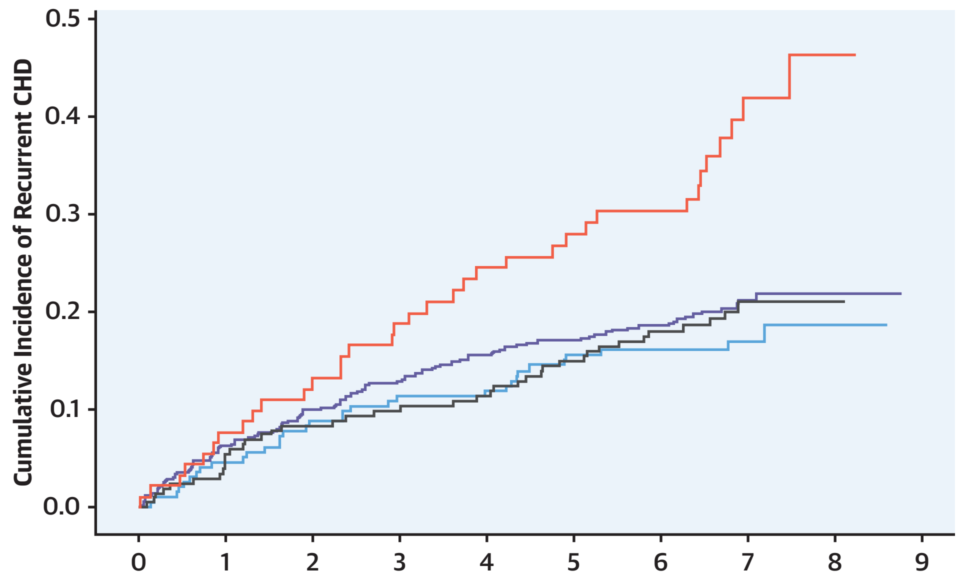
CENTRAL ILLUSTRATION Long Working Hours and Risk of Recurrent CHD in Patients Returning to Work After First Myocardial Infarction Episode

A



Number of Worked Hours	0	1	2	3	4	5	6	7	8	9
<35 h/Week	195	184	176	171	169	161	157	73	4	0
35-40 h/Week	474	441	423	404	390	376	363	155	6	0
41-54 h/Week	204	192	184	179	176	166	158	68	2	0
≥55 h/Week	94	84	79	72	66	62	59	26	2	0

B

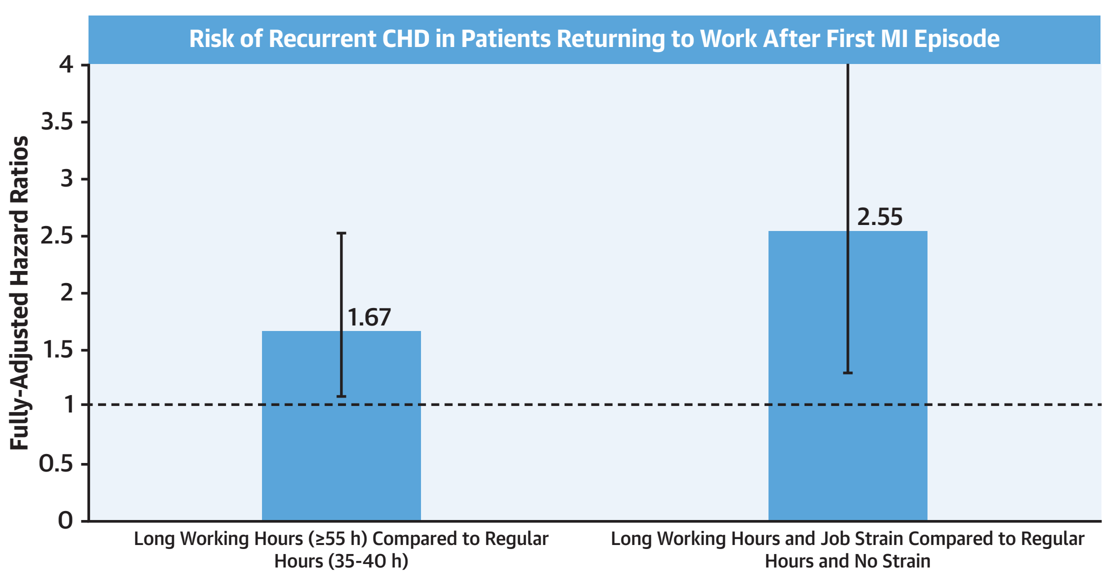


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TABLE 2 Hazard Ratios of Recurrent Coronary Heart Diseases Events by Weekly Working Hours

Weekly Working Hours	Number of Cases/Total	Person-Yrs	Event rate/ 100 Person-Yrs	Crude	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
<35	33/196	1,190.64	2.77	0.80 (0.54–1.19)	0.81 (0.55–1.21)	0.80 (0.54–1.19)	0.86 (0.57–1.28)	0.86 (0.58–1.29)	0.88 (0.59–1.33)	0.87 (0.58–1.31)
35-40	97/476	2,784.15	3.48	1.00	1.00	1.00	1.00	1.00	1.00	1.00
41-54	40/204	1,223.78	3.27	0.94 (0.65–1.36)	0.95 (0.65–1.38)	0.96 (0.66–1.39)	1.00 (0.68–1.46)	0.95 (0.65–1.39)	0.93 (0.63–1.36)	0.94 (0.64–1.38)
≥55	35/95	495.13	7.07	2.00 (1.36–2.95)	1.98 (1.34–2.94)	1.86 (1.25–2.77)	1.79 (1.20–2.68)	1.75 (1.17–2.62)	1.71 (1.14–2.58)	1.67 (1.10–2.53)

Values are hazard ratio (95% confidence interval) unless otherwise indicated. Model 1: adjusted for age, sex, education, marital status, and perceived economic situation, Model 2: Model 1 + prior comorbid conditions, thrombolysis, discharge medications, and number of coronary events during hospitalization. Model 3: Model 2 + hypertension, dyslipidemia, diabetes, and family history of cardiovascular disease. Model 4: Model 3 + smoking status, physical activity, body mass index, and alcohol intake. Model 5: Model 4 + job strain, social support at work, and physical and chemical exposure at work. Model 6: Model 5 + social support outside work, psychological distress, and personality factors.

for each 10-h increase were as follows: $HR_{50h/week}$: 1.20; 95% CI: 1.02 to 1.39; $HR_{60h/week}$: 1.50; 95% CI: 1.07 to 2.09; $HR_{70h/week}$: 1.92; 95% CI: 1.06 to 2.88; $HR_{80h/week}$: 2.46; 95% CI: 1.41 to 4.29; $HR_{90h/week}$: 3.10; 95% CI: 1.19 to 5.30; $HR_{100h/week}$: 3.78; 95% CI: 1.31 to 10.9). The fractional polynomial regression (**Figure 2**) showed that the risk of recurrent CHD associated with ≥55 h/week noticeably increased in magnitude after 4 years of follow-up.

DISCUSSION

The current study showed an increased risk of recurrent CHD events among patients who worked long hours after their first MI. This association was robust to adjustment for sociodemographic, clinical, and lifestyle-related risk factors as well as other adverse exposures from the work environment and other psychosocial and psychological factors. Results suggest that the effect of long working hours on recurrent CHD events increases linearly following the 40-h standard week schedule threshold. The effect was of higher magnitude after 4 years of follow-up, corresponding to approximately 4 years after returning to work.

To our knowledge, no previous study has examined the relationship between long working hours and the recurrence of CHD events. One previous study suggests that the adverse effect of job strain on mortality could be stronger in patients with pre-existing conditions (8). Moreover, a previous study conducted by our research team using the same cohort of patients showed that job strain exposure is associated with an increased risk of recurrent CHD events (9). However, contrary to job strain, no previous study has examined the effect of long working hours among patients returning to work after a first MI. Our adjusted estimates (HR ranging from 1.67 to 2.0 in standard analysis and over 2.0 after 4 years of follow-up and within the highest levels of working hours) are consistent with a stronger risk associated with long working hours for post-MI patients. Indeed, these estimates are higher in magnitude when compared with a recently published meta-estimate (HR: 1.12) derived from studies conducted among disease-free populations at baseline (6). It is also noteworthy that the magnitude of the observed association is comparable to that of current smoking, an acknowledged risk factor for recurrent CHD events. In the present study, the fully adjusted HR associated with current smoking was 1.70 (95% CI: 1.00 to 2.89), which is consistent with previous evidence on this topic (32).

Our findings further suggest that participants exposed to both long hours and job strain could be at particular risk. This could be attributable to the deleterious effect of prolonged exposure to work stressors among those working longer hours. This result should, however, be interpreted with caution

CENTRAL ILLUSTRATION Continued

(A) Kaplan-Meier curves of recurrent coronary heart diseases events according to weekly working hours. Cumulative incidence curves of recurrent CHD and number of at-risk patients in each category of hours worked. Patients working ≥55 h/week after a first MI had a higher cumulative incidence of recurrent CHD when compared with patients working fewer hours. **(B)** Hazard ratios of recurrent coronary heart disease according to long working hours among patients returning to work after a first myocardial infarction. Hazard ratio of recurrent coronary heart diseases comparing **(left)** post-MI patients working ≥55 h/week and those working 35 to 40 h/week and **(right)** patients working ≥55 h/week and exposed to job strain with those working 35 to 40 h/week and no job strain. **Dashed line** indicates the null value of the hazard ratio on the vertical axis. Adjustment variables included sociodemographics, lifestyle-related risk factors, clinical risk factors, work environment factors, and personality factors. CHD = coronary heart disease; MI = myocardial infarction.

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TABLE 3 Hazard Ratios of Recurrent Coronary Heart Diseases Events by Weekly Working Hours According to Job Strain Exposure

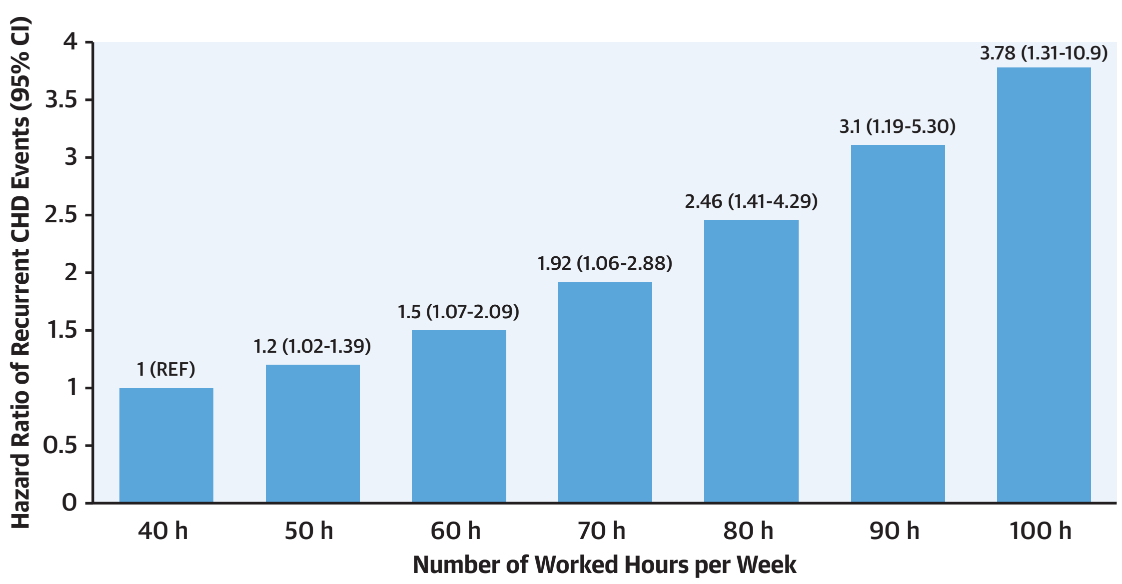
No job strain	
<35 h	0.76 (0.48–1.20)
35-40 h	1.00
41-54 h	0.78 (0.50–1.23)
≥55 h	1.34 (0.82–2.19)
High job strain	
<35 h	0.81 (0.48–1.36)
35-40 h	1.15 (0.51–2.60)
41-54 h	1.33 (0.70–2.51)
≥55 h	2.55 (1.30–4.98)

Values are hazard ratio (95% confidence interval). Adjusted for age, sex, education, marital status, perceived economic situation, prior comorbid conditions, thrombolysis, discharge medications, number of coronary events during hospitalization, hypertension, dyslipidemia, diabetes, family history of cardiovascular disease, smoking status, physical activity, body mass index and alcohol intake, social support at work, physical and chemical exposure at work, social support outside work, psychological distress, and personality factors.

given the reduced statistical power. Long working hours could exert an adverse effect on cardiovascular health through other mechanisms. For example, changes in lifestyle habits may be implicated. Indeed, previous studies have shown that people working long hours have a higher prevalence of smoking, physical inactivity, and alcohol consumption (33,34). Intermediate biological pathways, such as increased blood pressure and diabetes onset, are also potentially involved (35,36). In the present study, the effect of long working hours was observed after adjustment for these potential intermediate pathways. However, other unmeasured factors could be implicated, including sleep disturbances and atrial fibrillation (6).

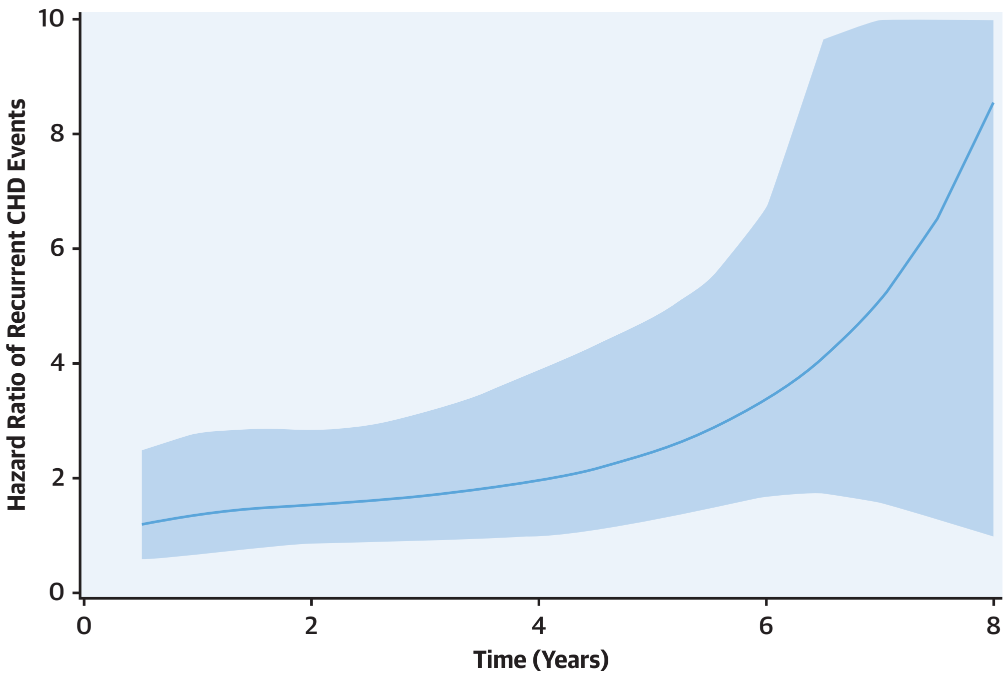
The timing of exposure is one crucial aspect to consider in assessing the impact of occupational exposures on "hard" CVD endpoints. The development of incident events could occur several years following exposure onset. The present study suggests that the effect of long working hours on CHD recurrence is of higher magnitude approximately 4 years following return to work. This finding could be explained by the need for a sufficient duration of exposure to be cumulated (chronic exposure), an induction period required for long working hours to exert its adverse effect, or both mechanisms (37). It is also consistent with a recent meta-analysis from the World Health Organization/International Labour Organization workgroup that suggested a slightly stronger effect of working ≥55 h/week on incident ischemic heart diseases in disease-free individuals after a certain period of follow-up time (in this case, 8 years of follow-up) (38). Future prospective studies should examine these important temporal aspects of the exposure-risk relationship. Adequate consideration of exposure-risk

FIGURE 1 Hazard Ratio of Recurrent Coronary Heart Diseases Events According to Weekly Working Hours Using Spline Regression



Spline regression examined the risk of recurrent coronary heart disease (CHD) events according to worked hours in its continuous form. Hazard ratios for selected levels of worked hours, for example, for each 10-h increase in weekly working hours when compared to 40 h/week. Adjustment variables included sociodemographics, lifestyle-related risk factors, clinical risk factors, work environment factors, and personality factors. CI = confidence interval.

FIGURE 2 Long Working Hours (≥55 h/week) and the Risk of Recurrent CHD Events Using Fractional Polynomial Regression



The **line** indicates the hazard ratio and the **shaded area** its 95% confidence interval. Adjustment variables included sociodemographics, lifestyle-related risk factors, clinical risk factors, work environment factors, and personality factors. The risk of recurrent coronary heart disease (CHD) event among patients who worked long hours was of higher magnitude 4 years following return to work.

windows would reduce the potential for an underestimation of the true effect of long working hours on CVD incidence and recurrence in future studies.

STUDY STRENGTHS AND LIMITATIONS. Our study has important strengths, including its relatively large sample size of workers from various job types and the long duration of follow-up. The participation was high (82%), minimizing the risk for selection bias. The outcome was defined as the first recurrent CHD event collected in patients' medical records and confirmed by a cardiologist and a vascular specialist who were blinded to patients' cardiovascular risk factors, increasing internal validity. Adjustment for a large number of CHD risk factors, sociodemographic, lifestyle, clinical prognosis, and work-environment characteristics has strongly reduced the potential for confounding bias. Last, the examination of exposure and time using flexible modeling statistical tools has allowed us to provide additional information on the period of time required for long working hours to exert its adverse effect on CHD recurrence.

Our study also has limitations. First, the small number of women limited the possibility to examine sex differences in the association between long working hours and recurrent CHD. Indeed, the fact that CVD events generally occur later in women's lives limited our ability to have an even distribution of men and women returning to work after a first MI. Second, long working hours was assessed at baseline only. Some patients could have changed exposure during follow-up, leading to potential nondifferential misclassification and to an underestimation of the true effect. Future studies, with larger sample size, should consider examining the effect of cumulative exposure. Finally, the generalization of this study's findings may be restricted to MI patients returning to paid work in OECD countries.

CONCLUSIONS

This prospective cohort study showed that post-MI patients who worked long hours after their first event may have an increased risk of recurrent CHD events. Secondary prevention interventions aiming to reduce the number of working hours among these patients may lower the risk of CHD recurrence. Long working hours should be assessed as part of early and subsequent routine clinical follow-up to improve the prognosis of post-MI patients.

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PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL OUTCOMES: Working long hours after a first MI is associated with an increased risk of recurrent coronary events.

TRANSLATIONAL OUTLOOK: Among survivors of myocardial infarction, secondary prevention interventions to reduce work hours should be evaluated for the effect on risk of recurrent ischemic events.

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KEY WORDS cohort study, epidemiology, risk factors, work stressors

APPENDIX For a supplemental table, please see the online version of this paper.