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## Original Contribution

# Primary Cardiovascular Disease Risk Factors Predicted by Poor Working Conditions in the GAZEL Cohort

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The mechanisms by which work environment might influence cardiovascular disease (CVD) risk are still a matter of debate. In particular, the involvement of the main behavioral and clinical risk factors and their relationships with working conditions are not always clear, despite an abundant body of literature. Most studies have investigated the impact of a limited number of characteristics of the work environment on the occurrence of 1 or a few risk factors. In contrast, in this study we used a global approach in which 30 objective and subjective indicators of working conditions were tested as predictors of 9 modifiable CVD risk factors in a well-characterized cohort of 20,625 middle-aged French workers who were followed from the 1990s until they retired or until December 31, 2013. The incidence of 3 CVD risk factors (obesity, sleep complaints, and depression) was predicted by a large number of indicators of working conditions in both age- and sex-adjusted and multivariate-adjusted Cox regression models, whatever the significance threshold retained. These results suggest the existence of close relationships between a poor work environment and a higher risk of developing obesity, sleep complaints, or depression. These risk factors may contribute to increased CVD risk not only when workers are exposed to poor working conditions but also after retirement, as predictors of the appearance of other risk factors.

cardiovascular disease; cohort studies; risk factors; work environment

Abbreviations: CVD, cardiovascular disease; GAZEL, Gaz et Electricité.

Meta-analyses of prospective cohort studies suggest that indicators of poor working conditions, such as the presence of high demands combined with a low level of control (a situation called “job strain”), long working hours, shift work, or job insecurity, are associated with an increased risk of cardiovascular events (1, 2). This increased risk of both coronary heart disease and ischemic stroke is equally observed across strata of sex, age, socioeconomic status, and region (3–7).

The mechanisms by which poor working conditions might increase cardiovascular disease (CVD) risk are still largely uncertain (8). It has been suggested that these conditions may promote risky behaviors such as nonmoderate alcohol consumption, smoking, or physical inactivity, which have all been associated with job strain (9–11). It has also been hypothesized that poor working conditions may induce chronic psychological

stress, with its potential harmful effects on the cardiovascular system via the hypothalamic-pituitary-adrenal axis and the autonomic nervous system (12). This latter mechanism could explain the increased risk of hypertension or type 2 diabetes that has been associated with job strain or long working hours (13–16).

The approach usually followed is to look for an association, either cross-sectional or prospective, between an indicator of poor working conditions (such as job strain) and 1 or a few CVD risk factors. Such an approach is limited by the choice of the indicator, which only partly characterizes the work environment and may reflect different realities in different cohorts. This approach is also limited by the analysis of only 1 or a few risk factors, which can be differently distributed from one cohort to another. For instance, this may

explain why the evidence linking job strain and obesity is still conflicting (17, 18).

To circumvent these limitations, in the present study we used a more global approach in a well-characterized cohort of workers in which a large number of indicators reflecting poor working conditions were tested, without a prior hypothesis, as predictors of the incidence of the main behavioral and clinical CVD risk factors. The results showed that 3 risk factors—namely obesity, sleep complaints, and depression—are closely associated with poor working conditions in both men and women, making them plausible candidates for mediating, at least in part, the increase of CVD risk.

## METHODS

### Study population

The analyses were performed in a cohort of 20,625 middle-aged employees of the French national gas and electricity company (originally Electricité de France–Gaz de France; now separate entities), who were recruited in 1989 and followed until they retired or until December 31, 2013 (the Gaz et Electricité (GAZEL) cohort) (19). These workers were mainly of Caucasian origin and lived throughout France in various settings ranging from rural areas to urban centers; they have been shown to be very diverse in terms of their social, economic, and occupational status, health, and health-related behaviors (20). They were very motivated to participate in the GAZEL cohort study, as indicated by the high acceptance rate (45%) at the time of recruitment and the subsequent high rate of response (75%) to an annual self-administered questionnaire during the entire follow-up period, with less than 5% of the initial cohort never sending back any questionnaire. All of the workers gave written informed consent to participate in the current study, which received approval from the Ethics Evaluation Committee of the National Institute for Health and Medical Research (INSERM) and the National Committee for the Protection of Privacy and Civil Liberties.

### Assessment of working conditions

A total of 30 indicators describing working conditions were identified in the questionnaire completed annually by the workers (Table 1). Occupational grade was used as a general proxy for socioeconomic status, as it integrates educational achievement, skills required to obtain the job, and several job characteristics, such as long-term associated rewards (including but not limited to income) or decision-making latitude. Monthly income was nevertheless retained as a more restrictive indicator of socioeconomic status. Commuting time was considered as an indicator of working conditions. A series of objective indicators were used, such as working with the public, outdoor work, night work, regular work hours, on-call work, standing work posture, hard work posture, handling heavy loads, exposure to vibrations, working with a computer screen, working in the cold, working in the heat, exposure to noise, work involving specific risks (electrocution, gas intoxication, falls, machine injuries, burns, or road traffic accidents), and work administratively classified as unhealthy. Several subjective indicators were also retained,

some relatively basic, evaluating the extent to which work was considered physically demanding, nerve-wracking, or satisfactory, using 8-level scales. Other, more sophisticated indicators assessed decision latitude, psychological demands, and social support at work, which were used to estimate job strain and isostrain (21) or evaluated extrinsic effort and reward at work, which were used to estimate effort/reward imbalance in parallel with overcommitment (22).

### Determination of CVD risk factors

Twelve clinical or behavioral CVD risk factors were retained from the annual questionnaire, which contained information from a variety of inquiries into lifestyle and the occurrence of health events among the workers (Table 2). Sex and age were reported as such; parental history of CVD referred to the occurrence of coronary heart disease before age 60 years in the mother or father. Inquiries into the occurrence of hypertension, dyslipidemia, diabetes, and sleep complaints asked the respondent to report the condition if it had appeared during the past year. Body mass index was calculated from weight and height values reported by the workers and was expressed as weight (kg)/height (m)<sup>2</sup>. Depression was assessed with the Center for Epidemiologic Studies Depression Scale and defined as scores  $\geq 17$  in men and  $\geq 23$  in women (23). Questions about alcohol consumption and smoking referred to the respondent's habits during the week prior to completion of the questionnaire. Physical activity was defined as the practice of a sport, whatever its frequency (occasionally, regularly, or competitively).

### Statistical analyses

Each indicator of working conditions at baseline was independently tested as a predictor of the incidence of each modifiable CVD risk factor during follow-up. Note that the baseline date, and therefore the follow-up period, varied from one indicator to another, depending on the year when the inquiry was made (see Table 1 for a summary). Likewise, the number of workers included was variable from one indicator to another, depending on the rate of response to the inquiry (Table 1). Cox proportional hazards regression was used to compute hazard ratios and 95% confidence intervals after excluding workers who were exposed to the risk factor at baseline (numbers varied depending on the factor and the year taken as baseline; see Table 2 for the year 1989). Time to event was measured from baseline to the first detection of the risk factor, and events were censored at the time of retirement. For each regression, 3 models were applied: unadjusted, adjusted for sex and age, and multivariate-adjusted for all CVD risk factors (except the one whose incidence was being analyzed).

Predictors of the incidence of CVD risk factors were defined in various ways. Occupational grade was ordered into 3 categories (low for blue- and white-collar workers, middle for middle management, high for upper management), monthly income was classified into 3 groups ( $<€2,592$ ,  $€2,592$ – $€3,811$ , or  $>€3,811$ ;  $< \$2,752$ ,  $\$2,752$ – $\$4,046$ , or  $> \$4,046$  at the 2016 exchange rate ( $€1 = US\$1.061$ )), and one-way commuting time was divided into tertiles ( $<15$ ,  $15$ – $25$ , or  $>25$  minutes). Working with the public, outdoor work, night work, regular work

**Table 1.** Indicators of Working Conditions at Baseline Among Gas and Electricity Workers Who Were Followed Until They Retired<sup>a</sup>, GAZEL Cohort, France

Indicator of Working Conditions	No. of Persons	% <sup>b</sup>	Baseline Year	Mean Duration of Follow-up, years
Occupational grade			1989	11.5
Low	3,342	16.3		
Middle	11,537	56.2		
High	5,634	27.5		
Monthly income, € <sup>c</sup>			2002	3.3
<2,592	5,389	39.5		
2,592–3,811	5,181	38.0		
>3,811	3,076	22.5		
One-way commuting time, minutes			1989	11.5
<15	5,930	29.1		
15–25	7,559	37.2		
>25	6,858	33.7		
Working with the public			1989	11.5
No	10,960	60.3		
Yes	7,216	39.7		
Outdoor work			1989	11.5
No	9,520	49.6		
Yes	9,675	50.4		
Night work			1989	11.6
No	13,022	68.5		
Yes	5,995	31.5		
Regular work hours			1989	11.4
No	3,649	20.1		
Yes	14,478	79.9		
Working on call			1989	11.5
No	14,968	75.5		
Yes	4,869	24.5		
Standing work posture			1989	10.9
No	5,088	45.1		
Yes	6,184	54.9		
Hard work posture			1989	11.5
No	5,385	57.4		
Yes	3,999	42.6		
Handling heavy loads			1989	11.2
No	5,580	65.4		
Yes	2,957	34.6		
Exposure to vibrations			1989	11.1
No	5,635	72.1		
Yes	2,184	27.9		
Working with a computer screen			1989	11.7
No	2,527	14.0		
Yes	15,505	86.0		

Table continues

**Table 1.** Continued

Indicator of Working Conditions	No. of Persons	% <sup>b</sup>	Baseline Year	Mean Duration of Follow-up, years
Working in the cold			1994	6.9
No	5,594	73.3		
Yes	2,036	26.7		
Working in the heat			1994	6.9
No	5,609	75.1		
Yes	1,856	24.9		
Exposure to noise			1994	7.1
No	5,498	68.8		
Yes	2,492	31.2		
Work involving specific risks <sup>d</sup>			1989	11.4
No	6,607	35.8		
Yes	11,833	64.2		
Unhealthy work			1989	11.5
No	18,932	95.2		
Yes	950	4.8		
Physically demanding work			1989	11.5
Low	7,336	36.7		
Middle	7,423	37.2		
High	5,204	26.1		
Nerve-wracking work			1989	11.5
Low	7,053	34.7		
Middle	8,442	41.5		
High	4,832	23.8		
Satisfactory work			1991	9.7
Low	3,469	20.7		
Middle	7,127	42.5		
High	6,185	36.8		
Decision latitude			1997	5.1
T1	4,006	28.6		
T2	5,240	37.5		
T3	4,743	33.9		
Psychological demands			1997	5.1
T1	4,192	29.9		
T2	5,266	37.6		
T3	4,542	32.5		
Job strain			1997	5.1
Low	1,568	13.1		
Passive	2,276	19.0		
Active	4,359	36.4		
High	3,769	31.5		
Social support at work			1997	5.1
T1	4,266	30.7		
T2	5,347	38.5		
T3	4,291	30.8		

Table continues

Table 1. Continued

Indicator of Working Conditions	No. of Persons	% <sup>b</sup>	Baseline Year	Mean Duration of Follow-up, years
Isostrain			1997	5.1
No	8,756	73.4		
Yes	3,168	26.6		
Extrinsic effort			1998	4.4
T1	2,633	24.7		
T2	4,473	41.9		
T3	3,567	33.4		
Reward			1998	4.4
T1	3,329	31.2		
T2	3,738	35.0		
T3	3,606	33.8		
Effort/reward imbalance			1998	4.4
No	10,063	94.3		
Yes	610	5.7		
Overcommitment			1998	4.4
No	7,003	65.6		
Yes	3,670	34.4		

Abbreviations: GAZEL, Gaz et Electricité; T, tertile.

<sup>a</sup> The baseline year, follow-up period, and number of workers included in the analyses varied from one indicator to another.

<sup>b</sup> The percentages refer to the number of workers available for analysis of each indicator.

<sup>c</sup> <\$2,752, \$2,752–\$4,046, or >\$4,046 at the 2016 exchange rate (€1 = US\$1.061).

<sup>d</sup> Electrocutation, gas intoxication, falls, machine injuries, burns, or road traffic accidents.

hours, on-call work, standing work posture, hard work posture, handling heavy loads, exposure to vibrations, working with a computer screen, working in the cold, working in the heat, exposure to noise, work involving specific risks, and work administratively classified as unhealthy were all coded as binary variables (no/yes). Physically demanding work, nerve-racking work, and satisfactory work were reduced to 3-level scales (low, middle, high); decision latitude, psychological demands, social support, extrinsic effort, and reward at work were divided into tertiles; job strain was coded into 4 categories (low, passive, active, or high); and isostrain, effort/reward imbalance, and overcommitment were coded as binary variables (no/yes) (Table 1). In addition, a global measure of working conditions combining all of the indicators except those that were composite (job strain, isostrain, and effort/reward imbalance) was proposed by giving, for each indicator, a score of 1 to the nonexposed group, 2 to the exposed group, and (for ternary indicators) 1.5 to the intermediate group. For each worker, working conditions were estimated as the sum of the scores for all indicators divided by the number of available indicators. This global indicator, which is high when working conditions are poor, was categorized into tertiles (good, average, or poor) to test its association with incident CVD risk factors.

As adjustment factors at baseline or as measured outcomes during follow-up, sex, parental CVD, smoking, nonmoderate drinking (<14 or >27 drinks/week in men, <7 or >20 drinks/week in women), physical inactivity, obesity (body mass index  $\geq 30$ ), hypertension, dyslipidemia, diabetes, sleep complaints, and depression were all coded as binary variables (female/male for sex, no/yes for the others). Only age (range, 39–54 years) was divided into tertiles (Table 2).

A classical issue related to multiple testing is the risk of obtaining false-positive findings, which increases with the number of tests performed ( $n = 810 (30 \times 9 \times 3)$  in the present study). To take this problem into account, a Bonferroni correction can be applied in order to keep only the associations with  $P < 0.05/(810)$ , that is,  $P < 0.0001$ . However, this correction comes at the cost of increasing the probability of obtaining false negatives, which would be the case in the present study, where several well-known associations were observed with  $P$  values between 0.0001 and 0.05. Thus, rather than choose between keeping potential false positives or excluding potential false negatives, we report all associations with  $P < 0.05$ , leaving open the possibility of narrowing the significance threshold to 0.01, 0.001, or 0.0001. In any case, whatever the significance threshold, the conclusion reached remains the same—that is, the existence of a close association between poor working conditions and the risks of obesity, sleep complaints, and depression.

All analyses were performed with the statistical discovery software JMP 12 Pro (SAS Institute, Inc., Cary, North Carolina).

## RESULTS

### Associations between working conditions at baseline and incident CVD risk factors

Depending on the indicator, the follow-up period varied from 3.3 years to 11.7 years, and the number of workers analyzed ranged from 7,465 to 20,513 (Table 1).

Four indicators (occupational grade, decision latitude, social support at work, and isostrain) predicted the incidence of nonmoderate alcohol consumption (12.2–35.0 cases per 1,000 person-years, depending on the indicator), with multivariate-adjusted hazard ratios ranging from 0.86 to 1.18 (see Web Table 1, available at <https://academic.oup.com/aje>). The incidence of smoking (5.1 cases per 1,000 person-years) was predicted by only 1 indicator (one-way commuting time), with a multivariate-adjusted hazard ratio equal to 0.77 (Web Table 2). Seven indicators (monthly income, standing work posture, hard work posture, exposure to noise, physically demanding work, nerve-racking work, and overcommitment) and the global measure predicted the incidence of physical inactivity (11.9–51.7 cases per 1,000 person-years, depending on the indicator); multivariate-adjusted hazard ratios varied from 0.83 to 1.23 (Web Table 3).

The incidence of obesity was predicted by 18 indicators (occupational grade, monthly income, working with the public, outdoor work, night work, on-call work, standing work posture, hard work posture, handling heavy loads, working in the cold, working in the heat, exposure to noise, work involving specific risks, unhealthy work, physically demanding work, social support at work, reward, and effort/reward imbalance) and the global measure (6.3–26.6 cases per 1,000 person-years,

**Table 2.** Prevalence of Cardiovascular Disease Risk Factors at Baseline (1989) Among Gas and Electricity Workers, GAZEL Cohort, France

CVD Risk Factor	No. of Persons	% <sup>a</sup>
Sex		
Male	15,011	72.8
Female	5,614	27.2
Age, years		
39–45	6,805	33.0
46–49	6,808	33.0
50–54	7,012	34.0
Parental CVD		
No	13,519	87.7
Yes	1,890	12.3
Nonmoderate alcohol consumption		
No	3,764	22.7
Yes	12,829	77.3
Smoking		
No	14,617	71.5
Yes	5,832	28.5
Physical inactivity		
No	11,394	66.6
Yes	5,706	33.4
Obesity		
No	16,627	95.0
Yes	869	5.0
Hypertension		
No	18,880	91.5
Yes	1,745	8.5
Dyslipidemia		
No	18,118	87.8
Yes	2,507	12.2
Diabetes		
No	20,318	98.5
Yes	307	1.5
Sleep complaints		
No	16,667	80.8
Yes	3,958	19.2
Depression		
No	11,265	75.6
Yes	3,628	24.4

Abbreviations: CVD, cardiovascular disease; GAZEL, Gaz et Electricité.

<sup>a</sup> The percentages refer to the number of workers available for analysis of each risk factor.

depending on the indicator) (Web Table 4). Multivariate-adjusted hazard ratios ranged from 0.71 to 1.63.

The incidence of hypertension was predicted by 9 indicators (occupational grade, one-way commuting time, exposure to

noise, decision latitude, psychological demands, job strain, isostrain, extrinsic effort, and reward) and the global measure (13.4–41.1 cases per 1,000 person-years, depending on the indicator), with multivariate-adjusted hazard ratios varying from 0.80 to 1.39 (Web Table 5). Three indicators (occupational grade, monthly income, and reward) and the global measure predicted the incidence of dyslipidemia (18.2–73.5 cases per 1,000 person-years, depending on the indicator), with multivariate-adjusted hazard ratios ranging from 0.82 to 1.17 (Web Table 6).

Four indicators (occupational grade, monthly income, regular work hours, and overcommitment) and the global measure predicted the incidence of diabetes (3.3–13.3 cases per 1,000 person-years, depending on the indicator) (Web Table 7). Multivariate-adjusted hazard ratios varied from 0.75 to 1.29.

The incidence of sleep complaints was predicted by 23 indicators (monthly income, working with the public, regular work hours, standing work posture, hard work posture, handling heavy loads, exposure to vibrations, working with a computer screen, working in the heat, exposure to noise, work involving specific risks, physically demanding work, nerve-wracking work, satisfactory work, decision latitude, psychological demands, job strain, social support at work, isostrain, extrinsic effort, reward, effort/reward imbalance, and overcommitment) and the global measure (29.9–118.6 cases per 1,000 person-years, depending on the indicator). Multivariate-adjusted hazard ratios ranged from 0.68 to 1.58 (Web Table 8).

Nineteen indicators (monthly income, hard work posture, handling heavy loads, exposure to vibrations, working in the heat, exposure to noise, work involving specific risks, physically demanding work, nerve-wracking work, satisfactory work, decision latitude, psychological demands, job strain, social support at work, isostrain, extrinsic effort, reward, effort/reward imbalance, and overcommitment) and the global measure predicted the incidence of depression (8.8–39.9 cases per 1,000 person-years, depending on the indicator). Multivariate-adjusted hazard ratios varied from 0.40 to 2.32 (Web Table 9).

Web Table 10 shows multivariate-adjusted hazard ratios for all of the associations between the indicators of working conditions at baseline and incident CVD risk factors during follow-up. The number of indicators predicting the incidence of each risk factor varied greatly according to the factor and the selected significance threshold. This number was particularly high for 3 risk factors (obesity, sleep complaints, and depression), which were predicted by 18–23 indicators (excluding the global indicator) at  $P < 0.05$ , as compared with 1–9 for the other risk factors; this marked difference remained at more stringent significance thresholds (Table 3). Corroborating these observations, the global indicator predicted 7 out of 9 risk factors, with hazard ratios that were particularly high for obesity, sleep complaints, and depression (Web Table 10).

### Stratification on sex

Web Tables 11 and 12 show multivariate-adjusted hazard ratios for all of the associations between indicators of working conditions at baseline and incident CVD risk factors

**Table 3.** Number of Indicators of Baseline Working Conditions That Predicted the Incidence of Individual Cardiovascular Disease Risk Factors During Follow-up of Gas and Electricity Workers, According to Significance Threshold, GAZEL Cohort, France, 1989–2013<sup>a</sup>

Incident CVD Risk Factor	No. of Indicators			
	<i>P</i> < 0.05	<i>P</i> < 0.01	<i>P</i> < 0.001	<i>P</i> < 0.0001
Nonmoderate alcohol consumption	4	1	0	0
Smoking	1	1	0	0
Physical inactivity	7	3	1	1
Obesity	18	15	8	5
Hypertension	9	5	2	0
Dyslipidemia	3	2	0	0
Diabetes	4	0	0	0
Sleep complaints	23	21	16	15
Depression	19	17	14	12

Abbreviations: CVD, cardiovascular disease; GAZEL, Gaz et Electricité.

<sup>a</sup> The table shows the associations observed in multivariate-adjusted models. Note that the baseline date, and therefore the follow-up period, varied from one indicator of working conditions to another depending on the year in which the inquiry was made (see Table 1).

during follow-up in men and women, respectively. Despite the unbalanced sex ratio of the cohort and the relative lack of statistical power for women, it appeared that the number of indicators predicting the incidence of obesity, sleep complaints, and depression was high in both sexes at all significance thresholds (Table 4).

## DISCUSSION

The purpose of the present study was to provide a global view of the relationships between work environment and incidence of the main behavioral and clinical risk factors for CVD. A large number of indicators of working conditions

were tested for their ability to predict the incidence of each risk factor in a cohort of middle-aged workers (the GAZEL cohort) who were followed until they retired. The whole set of indicators gives a rather complete description of the work environment according to both objective and subjective characteristics, some of which are rarely used to prospectively study relationships with health problems. This approach showed that the incidence of 3 CVD risk factors—namely obesity, sleep complaints, and depression—was predicted by a high number of indicators of working conditions in both men and women, suggesting the existence of close relationships between the work environment and the risk of developing these pathologies. This closeness was also suggested by

**Table 4.** Number of Indicators of Baseline Working Conditions That Predicted the Incidence of Individual Cardiovascular Disease Risk Factors During Follow-up of Gas and Electricity Workers, According to Sex and Significance Threshold, GAZEL Cohort, France, 1989–2013<sup>a</sup>

Incident CVD Risk Factor	No. of Indicators							
	Men				Women			
	<i>P</i> < 0.05	<i>P</i> < 0.01	<i>P</i> < 0.001	<i>P</i> < 0.0001	<i>P</i> < 0.05	<i>P</i> < 0.01	<i>P</i> < 0.001	<i>P</i> < 0.0001
Nonmoderate alcohol consumption	4	1	0	0	0	0	0	0
Smoking	1	0	0	0	3	0	0	0
Physical inactivity	8	2	0	0	4	1	0	0
Obesity	17	10	4	3	9	3	2	1
Hypertension	6	5	0	0	6	3	1	0
Dyslipidemia	1	1	0	0	2	0	0	0
Diabetes	3	0	0	0	0	0	0	0
Sleep complaints	19	18	14	11	19	17	11	6
Depression	15	14	12	11	15	10	8	4

Abbreviations: CVD, cardiovascular disease; GAZEL, Gaz et Electricité.

<sup>a</sup> The table shows the associations observed in multivariate-adjusted models. Note that the baseline date, and therefore the follow-up period, varied from one indicator of working conditions to another depending on the year in which the inquiry was made (see Table 1).

the indicator used to globally characterize working conditions, which was strongly associated with incidence of the same 3 risk factors.

The evidence that working conditions may influence the risk of sleep disturbances was recently compiled in a systematic review of available prospective studies (24). Several indicators of the work environment (social support at work, organizational justice, control, demands, job strain, reward, effort/reward imbalance, bullying, and shift work) reached a sufficient level of evidence to support the claim that they probably affect how workers sleep. All of these indicators were also found to be predictors of the risk of sleep complaints in the present study, except organizational justice, bullying, and shift work, which were not investigated as such. On the other hand, many other objective or subjective indicators predicted the risk of sleep complaints in our study with similar hazard ratios and statistical significance. Some of these indicators were evaluated with an insufficient level of evidence in the aforementioned review (regular work hours, handling heavy loads, work involving specific risks, and physically demanding work), while others were not even cited (monthly income, working with the public, standing work posture, hard work posture, exposure to vibrations, working with a computer screen, working in the heat, exposure to noise, nerve-racking work, satisfactory work, isostrain, extrinsic effort, and overcommitment), indicating that the research has been focused on only a handful of characteristics of the work environment.

The evidence of a link between working conditions and the risk of depression was also recently reviewed (25). Several indicators of the work environment were reported as potential causes of depression with a high (job strain, decision latitude, bullying) to moderate (psychological demands, effort/reward imbalance, low support at work, unfavorable social climate, lack of work justice, workplace conflicts, limited skill discretion, job insecurity, long working hours) level of evidence. The present study is in agreement with that review, given that when the same indicators were tested (job strain, decision latitude, psychological demands, effort/reward imbalance, low support at work), they indeed predicted the risk of developing depressive symptoms. Some of the reviewed indicators (bullying, unfavorable social climate, lack of work justice, workplace conflicts, limited skill discretion, job insecurity, long working hours) were not tested as such in our study, but many other objective or subjective indicators were found to predict the risk of depression with similar hazard ratios and statistical significance, although they were considered to have an insufficient level of evidence (work involving specific risks, physically demanding work) or were absent from the review (monthly income, hard work posture, handling heavy loads, exposure to vibrations, working in the heat, exposure to noise, nerve-racking work, satisfactory work, isostrain, extrinsic effort, reward, overcommitment). As for sleep complaints, this underlines the need to develop a more global approach for investigating the potential impact of the work environment on the risk of depression.

Given that sleep complaints are a common symptom of depression and that one of the items used to define depression pertains to restless sleep, these risk factors are highly correlated, and it is not surprising that many of the indicators of

working conditions predicting the risk of sleep complaints also predict the risk of depression. To confirm the results of the multivariate models in which the two factors were adjusted for each other, we assessed the number of indicators predicting the risk of sleep complaints or depression in subsamples of the cohort who were respectively free of depression or sleep complaints at baseline and during follow-up. Web Table 13 shows that the results in the subsamples were very similar to those obtained with the adjusted models in the whole cohort, suggesting that sleep complaints and depression are independently predicted by a large number of indicators of working conditions despite their high degree of correlation.

The most striking finding of our study is probably the observation that the risk of obesity was predicted by numerous indicators of working conditions. The inverse association with occupational grade and monthly income is in agreement with the well-known link between socioeconomic status and the risk of becoming obese (26). In contrast, it is noteworthy that job strain and its components (decision latitude, psychological demands) were not found to be predictors of the risk of obesity as suggested by a recent meta-analysis of prospective studies (17). Our analyses additionally showed that many other objective or subjective indicators of the work environment (working with the public, outdoor work, night work, on-call work, standing work posture, hard work posture, handling heavy loads, working in the cold, working in the heat, exposure to noise, work involving specific risks, unhealthy work, physically demanding work, social support at work, reward, and effort/reward imbalance) are predictors of the risk of obesity. The published evidence for most of these indicators is either totally absent or very scarce (27), emphasizing the need for new investigations in this field.

Censoring incident events at the time of retirement allowed us to analyze the appearance of CVD risk factors while workers were exposed to the work environment and to avoid any mitigating effect of the retirement period. Our results therefore suggest that obesity, sleep complaints, and depression are early consequences of poor working conditions. Although these factors independently increase CVD risk (28–31), they also predict the appearance of other risk factors. For example, obese workers have a much higher risk of developing hypertension or diabetes (32, 33). In addition, there is consistent evidence of reciprocal predictive relationships between obesity and depression (34), as well as between sleep complaints and depression (35), that can potentially reinforce the risk of appearance of these factors.

It must be emphasized that the 30 indicators used to describe the working conditions are not independent of each other. As is shown in Web Table 14, each indicator is correlated with most of the others, and sometimes with all of the others. Testing them separately for their ability to predict the appearance of CVD risk factors nevertheless remains meaningful, as each indicator offers a slightly different way to assess the complexity of the work environment. The number of indicators predicting a risk factor can then be viewed as the extent of the relationship between this factor and the work environment as a whole. It can also be noted that the high degree of correlation among the indicators does not mean that each of them has an equivalent impact on CVD risk. Web Table 10 shows that the number of risk factors whose incidence is predicted

by a given indicator varies substantially, some (monthly income, occupational grade, exposure to noise, reward) predicting the incidence of several risk factors while others (outdoor work, night work, on-call work, working in the cold, unhealthy work) predict the incidence of only 1 factor.

The present analyses had some limitations. A first one is that the characteristics of both the work environment and cardiovascular health were self-reported and may therefore have been relatively imprecise. Concerning the risk factors, the potential issue is underreporting with a rate that varies substantially from one factor to another, as was previously shown by a comparison with medical diagnoses obtained from the sick-leave database of the company (36). It is particularly the case for obesity, the prevalence of which has been found to be underestimated by approximately 20% (37). Nevertheless, it is unlikely that this imprecision was a major concern in the present study, which only investigated the existence of prospective associations without attempting to accurately determine prevalence or incidence rates. This view is supported by the very similar patterns of association that were observed at baseline between the indicators of working conditions and either measured or self-reported obesity (Web Table 15). A second limitation was the lack of information concerning the potential evolution of working conditions during follow-up, which likely weakened the associations with the incidence of CVD risk factors, given that most of these conditions probably improve with time as workers move up the job ladder, thus reducing their exposure and therefore the probability of appearance of the risk factors.

In conclusion, this study showed that a poor work environment, assessed via many objective and subjective indicators, primarily predicts the appearance of 3 CVD risk factors—obesity, sleep complaints, and depression—which greatly affect work productivity but are potentially modifiable. These factors may contribute to an increase in CVD risk during time periods in which workers are exposed to a poor work environment and later on, after retirement, by increasing the probability of the appearance of other risk factors. These 3 pathologies also have several other deleterious consequences besides increasing CVD risk, which can further add to the health burden experienced by affected workers.

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