Effects of Environmental and Organizational Factors on the Health of Shiftworkers of a Printing Company

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This study explored the effects of environmental and organizational stressors on the health of shiftworkers in a printing company (n = *124). A questionnaire was used to gather data on work history, organizational factors, psychosocial characteristics, medical history, present health, occupational and non-occupational exposures, and lifestyle factors. The perception of environmental and organizational conditions was associated* ($P < 0.05$) *with chronic back pain (odds ratio [OR], 1.29), varicose veins (OR, 1.35), allergic rhinitis (OR, 1.27), depression (OR, 1.45), and gastritis (OR, 1.15). Anxiety scores were associated with allergic rhinitis (OR, 1.14) and skin allergy (OR, 1.09). Shiftwork was a significant risk factor for conjunctivitis (OR, 3.68), depression (OR, 0.23), cardiac arrhythmia (OR, 7.13), and gastritis (OR, 4.38). Other associations included tenure and chronic back pain (OR, 4.89), toluene exposure and skin allergy (OR, 3.76), worksite and conjunctivitis (OR, 7.0), and worksite and dermatitis (OR, 1.24 to 4.95). The number of hours of exercise per week was associated with varicose veins (OR, 4.33), and alcohol intake was associated with cardiac arrhythmia (OR, 6.74).* (J Occup Environ Med. *2001;43:882–889*)

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Several stressors are part of the daily life of workers. A variety of factors related to work environment, job content, organizational issues, and individual characteristics can influence work performance, job satisfaction, and health.[1] In the past 20 years, there has been a steady progression in the study of associations among work environment, organizational and psychosocial factors, and adverse health outcomes.[2–5] The focus of the current approach was to identify the critical components of work life that can affect health and the extent to which these components interact.[6] A holistic approach to the study of work that considers biological, psychological, and sociological information can be expected to help identify occupational disorders and provide a healthier and more satisfactory work life.[5–7]

The present cross-sectional study was part of another study published elsewhere[8]; it examined the effects of combined environmental and organizational stressors on workers' health by using a comprehensive questionnaire and evaluating hazardous exposures in the workplace. Self-rated measures have been used successfully to determine the nature and intensity of stressors in the workplace[9] and to measure health.[10,11] Even though a cross-sectional design does not allow prediction of the long-term consequences of work stressors on health and well-being, it does allow the identification of problems and their association with various factors. Consequently, the design

contributes to the development and implementation of needed interventions and health promotion measures to prevent further health deterioration.[12]

Methods

Study Population

Subjects were male workers employed for a minimum of 1 year who were working in a printing company in São Paulo, Brazil. All of the workers from the departments of Rotogravure Printing, Paint Preparation, Engraving, Lamination, Color Proofing, and Cylinder Preparation who met the eligibility criteria (minimum of 1 year's tenure) accepted the invitation to participate in the study ($n = 124$). Their identities were kept confidential. The mean tenure of the study group at the company was 7 years, ranging from 1 to 25 years. The mean age of the study group was 33.8 years, ranging from 21 to 58 years. During data collection, participants worked in 8-hour shifts (6:00 AM to 2:00 PM, 2:00 PM to 10:00 PM, and 10:00 PM to 6:00 AM) that rotated monthly. Twelve of the participants worked in 12-hour monthly rotating shifts from 6:00 AM to 6:00 PM and 6:00 PM to 6:00 AM. In alternate weeks, the participants worked on Saturdays, completing 48 hours of work in a week.

Organic Solvent Exposure Assessment

The participants were exposed to solvent mixtures composed mainly of toluene, ethyl alcohol (ethanol), and ethyl acetate. To determine the exposure level to these predominant solvents, personal, full-shift time-weighted average exposure evaluations were conducted on all subjects using US National Institute for Occupational Safety and Health (NIOSH) Methods 1501, 1400, and 1457.[13] The concentration of the mixture in the air relative to exposure limits was calculated by using the American Conference of Governmental Industrial Hygienists (ACGIH) formula for mixtures with additive effects, the Brazilian exposure limits for ethyl acetate (1090 mg/m^3) and ethanol (1480g/m^3), and the ACGIH Threshold Limit Value for toluene (188 mg/m^3).[14,15] Levels of ethanol in air ranged from below the detection limit of 0.25 to 1240 mg/m^3, and its exposure index never exceeded unity. Ethyl acetate concentrations in air ranged from 1.1 to 2635 mg/m^3. The highest ethyl acetate concentrations (time-weighted average) were observed in the Rotogravure Printing and Lamination departments, where the exposure indices were greater than 1 for some job categories. Levels of toluene in air ranged from 0.14 to 919 mg/m^3. The highest toluene levels were observed in the Engraving and Rotogravure Printing departments, the only areas in which the exposure index exceeded unity. When exposure indices were calculated for the mixture of the three solvents, toluene was often the major component, and in some instances it caused the resulting exposure index to be greater than 1. Chemicals were not used in Cutting and Packing areas, resulting in very low concentrations of chemical agents in the air. Descriptions of the assessment methods and workers exposures are detailed elsewhere.[8]

Noise Exposure Assessment

Sound pressure measurements revealed continuous noise levels in the range of 71 to 93 dBA. The Brazilian (and NIOSH) recommended limit of 85 dBA and the 5-dB exchange rate were used in these evaluations. Noise dosimetry, conducted with Brüel & Kjaer (Nærum, Denmark) dosimeters model 4436, indicated doses that ranged from 43% to 300%. Most of the exposures were below the recommended exposure limits, and the workers with longer tenure are exposed to lower noise and solvent levels.[8]

Questionnaire

According to the stress-strain concept,[16] working conditions and work organization characterize the workload (stressors). In the present investigation, data were collected through an interview based on a questionnaire containing approximately 400 items on psychosocial aspects of work, work history, work organization, medical history, present health, stress, occupational and non-occupational exposure, and lifestyle factors. Strain was represented by items regarding self-assessed health consequences (subjective health state) and diagnosed diseases.

The interview protocol was partially based on the Standard Shiftwork Index[17] and was developed after site visits, 10 preliminary interviews, and ergonomic evaluations of the workplaces (see a list summarizing the sections of the questionnaire in the Appendix). The selection of questions related to the working conditions, health complaints, and diseases were chosen on the basis of the workers' interviews and observations made during the ergonomic evaluations. Several types of responses were required by the questionnaire: yes/no; never, seldom, sometimes, often; adequate, regular, bad, very bad; a lot, some, a little; number or frequency of activities and consumption (times per day, weeks per month); period (day or night, weekends); use of medication (1 = no, 2 = yes); symptoms of a certain disease (1 = never, 2 = rarely, 3 = sometimes, 4 = always); diagnosed diseases (1 = never, 2 = before current employment, 3 = after current employment); perceived environmental and organizational conditions (1 = adequate, 2 = regular, 3 = bad, 4 = very bad); work control, (1 = always, 2 = often, 3 = sometimes, 4 = rare or none); social support at the workplace (yes/no); fear at work (never, rare, sometimes, often); and anxiety symptoms (none, a little, a lot). Depending on the section of the questionnaire, answers were converted into scores. The sum of scores for each topic was calculated for each individual. The higher the score, the more negative the

working conditions or the health, social, or family effects. Other authors have used similar procedures for measuring the health, psychosocial well-being, and attitudes of shiftworkers.[10,18,19] Such methods were used here for questions related to health symptoms, diagnosed diseases, anxiety symptoms, psychological stressors, work control, social support at work, and minor emotional problems. Social and workplace factors included variables describing physical and organizational work conditions and variables that, in part, reflect the person's appraisal of the stress and strain induced by work conditions. Variables in these categories can be found in the Appendix. They include ratings of the perception of shiftwork, perceived environmental and organizational conditions, psychological job demands, work control, workplace social support, fear at work, and anxiety symptoms. The group of questions concerning psychological job demands, work control, and workplace social support are constructed scales[20] that measured aspects of psychosocial factors in the work environment.

Medical history items were surveyed for their time of onset (never, before current employment, after current employment). Diagnosed diseases, such as diabetes and high blood pressure, were reported as positive if the employee was diagnosed or was receiving treatment for the listed condition. Fifty-eight symptoms were queried using a four-point scale (never to very frequently). Habits of coffee and alcohol consumption, exercise habits, and body mass index were also surveyed.

Data Analysis

This report focuses on the analysis of diseases that occurred after the workers began their tenure at the company. The list of diseases totaled 34, and for each one the responses could be (1) never diagnosed, (2) diagnosed before current employment, and (3) diagnosed after current employment. Because of the low prevalence of some, and the confounding effects that can trigger others, the risk factors for only nine of the reported outcomes were analyzed: chronic back pain, varicose veins, allergic rhinitis, dermatitis, skin allergy, conjunctivitis, depression, cardiac arrhythmia, and gastritis. The risk factors for these outcomes were examined using multiple logistic regression analysis. The dependent variables were the disease states (never = 0, after current employment = 1). The independent variables considered for inclusion in the models were age, tenure, marital status, years of education, hours of sleep, family income, exercise habits, body mass index, time in shiftwork, occupational exposure data for solvents and noise, worksite, job category, alcohol and coffee consumption (amount per day times number of years), smoking (number of cigarettes per day times the number of years of smoking), scores for the perception of environmental and organizational work conditions, and psychological stressors (including work control, fear at work, social support, and anxiety). A separate analysis using unconditional multiple logistic regression was performed for each disease.

In univariate analysis, some independent variables were analyzed by terciles or quartiles, and categories that presented similar risks were grouped to reduce the number of numerator degrees of freedom. Some of the independent variables, such as perceived environmental and organizational conditions, work control, social support at work, anxiety, and fear at work, were entered as continuous variables. Interpretation of the regression coefficients (β) depends on the type of independent variable. For dichotomous variables, the estimate of the odds ratio (OR) is $\exp[\beta]$. For continuous variables, the estimate of the OR depends on a meaningful change in the independent variable (X), $OR = \exp[\beta \Delta Xi]$.[21] The forward stepwise procedure was used for selecting variables. A variable was retained in the model if $P < 0.05$ or if it was known to be a confounding variable. The Wald test was used to evaluate the statistical significance of the OR. The data were analyzed using the Statistical Analysis System (1996) and Statistical Product and Service Solutions (1997) software.

Results

The frequencies of the diseases diagnosed before and after the workers were employed by the printing company are presented in Table 1. After employment, significant increases in frequency were found for 14 of the 34 different health outcomes reported.

We analyzed the risk factors for nine of the health outcomes that increased in frequency after employment. The other five outcomes (arthritis, sinus problems, vision problems, angina pectoris, and hypertension) were not examined further because it was unlikely that they were work-related and there were only a small number of cases. Table 2 gives the results of the final multiple logistic regression models for the risk factors for developing each of the health outcomes.

The perception of environmental and organizational conditions was associated with several health outcomes: chronic back pain (OR, 1.29), varicose veins (OR, 1.35), allergic rhinitis (OR, 1.27), depression (OR, 1.45), and gastritis (OR, 1.15). Scores from the anxiety section of the questionnaire were found to be associated with allergic rhinitis (OR, 1.14) and skin allergy (OR, 1.09). Time in shiftwork was estimated to be significant risk factor for conjunctivitis (OR, 3.68), cardiac arrhythmia (OR, 7.13), and gastritis (OR, 4.38). For depression, a longer time in shiftwork was associated with better coping strategies (OR, 0.23).

Working conditions were associated with several outcomes: tenure and chronic back pain (OR, 4.89), worksite and dermatitis (OR, 1.24 to 4.95), toluene exposure and skin al-

TABLE 1
Percentage of Workers With Diseases Diagnosed Before and After Employment in a Printing Company, São Paulo

Diseases	Percentage		
	Never	Before	After
Chronic back pain*	66.9	9.7	23.4
Vertebral column hernia	97.6	1.6	0.8
Arthritis	92.7	0.8	6.5
Asthma	93.5	2.5	4.0
Sinus	79.8	8.1	12.1
Amigdalitis	83.0	8.9	8.1
Frequent colds, flu	53.2	29.9	16.9
Pneumonia	87.9	4.8	7.3
Allergic rhinitis*	77.4	6.5	16.1
Gastritis*	75.8	8.9	15.3
Ulcer	97.6	1.6	0.8
Colitis	97.6	0.8	1.6
Gallbladder problems	99.2	0.0	0.8
Conjunctivitis*	68.5	13.8	17.7
Vision problems	75.0	10.5	14.5
Ear infection	90.3	2.4	7.3
Varicose veins*	82.3	4.8	12.9
Hemorroids	97.6	0.0	2.4
Angina pectoris	95.2	0.8	4.0
Myocardial infarction	100.0	0.0	0.0
Cardiac arrhythmia*	94.4	0.0	5.6
Hypertension	89.5	1.6	8.9
Anemia	95.2	2.4	2.4
Diabetes	97.6	0.8	1.6
Cystitis	99.2	0.0	0.8
Kidney stones	96.0	0.8	3.2
Other kidney problems	94.4	2.4	3.2
Prostate	100.0	0.0	0.0
Hepatitis	97.6	1.6	0.8
Leptospirosis	100.0	0.0	0.0
Herpes	96.8	2.4	0.8
Skin allergy*	70.1	7.3	22.6
Dermatitis*	75.8	7.3	16.9
Depression*	81.5	5.6	12.9

* Risk factors were analyzed by multiple logistic regression only for the diseases marked with an asterisk, because those showed the higher number of cases and can be work-related.

lergy (OR, 3.76), and worksite and conjunctivitis (OR, 7.0).

Few non-occupational factors were found to be associated with the diagnosed health outcomes. The absence of physical exercise was found to be associated with varicose veins (OR, 4.33), and alcohol intake was associated with cardiac arrhythmia (OR, 6.74).

Discussion

Most occupational studies seek to shed light on the association between health outcomes and exposure to hazards or organizational factors. In the latter case, investigators will take into account the worker's perception of the work environment. In the present study, in which potentially hazardous exposures were measured and each subject underwent an extensive interview, we evaluated how occupational factors contributed to the diagnosed health outcomes in this population of printing workers.

This study investigated the association of work environment (actual measurements of hazards and perceived work conditions) and organizational factors with health outcomes in a group of workers from a printing company in São Paulo, Brazil. In most instances, current exposures to hazards such as solvents and noise were found to be below the recommended values. Even though the group was relatively young (mean age, 34 years), the elevated prevalence of a series of health outcomes was observed. Limitations of this study are its cross-sectional design and the small number of cases of disease, which can lead to large confidence intervals and a loss of statistical significance ($P > 0.05$). Some variables were kept in the multiple regression models to indicate that these factors that can affect workers' health, especially those in poor working conditions.

Studies conducted in the past decade have indicated that socioeconomic factors, physical and psychosocial characteristics of the work environment, and self-perceived health are predictors of retirement age and of disability retirement.[22] The observations of the present study confirm that the combination of individual characteristics (such as an unhealthy lifestyle), a risky and unhealthy work environment, and organizational factors that are difficult to cope with are related to general health deterioration.

Some of the associations reported in the present study have been reported previously. Slightly elevated ORs in the present investigation indicate associations between perceived environmental and organizational factors and outcomes such as allergic rhinitis, depression, and gastritis, all of which have been associated with stress.[23]

The ORs (1.29) reported in the present investigation for chronic back pain and for environmental and organizational factors were comparable with the ORs (ranging from 1.3 to 2.4) reported in several previous studies.[24] The association between tenure and back pain suggests that certain job tasks and ergonomic issues contribute to the condition. The number of studies that have addressed work-related psychological risk factors for back disorders is considerably smaller than the number of investigations on the physical demands of the job. However, the consistency of the recent findings implicating psychosocial factors as risk factors may change this trend. It still remains to be explained whether the factors are causal or are merely aggravating back pain and disability.[24] It has been argued that these factors might influence the reporting of back disorders and could be regarded as effect modifiers.[25]

No associations have been previously reported between back pain and family income. In this study, family income may be a surrogate of job function. Higher incomes were associated with skilled jobs in which workers performed their work tasks with bad postures. In the case of chronic back pain, heavy lifting and bad posture were common practices among shiftworkers performing their tasks.

Another important variable related to lifestyle, the low frequency of physical exercise, was associated with varicose veins and with bad working conditions.

Solvent exposure was found to be associated with specific outcomes, such as conjunctivitis (OR, 7.0) and

TABLE 2
Results of the Multiple Logistic Regression for Health Outcomes After Workers Began Working in a Printing Company

Health Outcomes and Risk Factors	Category	Cases*		Non-Cases				
		n	%	*n*	%	OR	CI	*P*
Chronic back pain								
Perceived EOC	Continuous	*29*	*25.9*	*83*	*74.1*	1.29	1.11–1.52	0.0013
Monthly family income (US $)	215–565†	7	25.0	21	75.0	2.74	0.52–14.40	0.2334
	565–904	18	28.6	45	71.4	9.33	2.35–37.01	0.0015
	≥904	4	19.0	17	81.0	1	Baseline	
Tenure	<10 years‡	17	22.1	60	77.9	1	Baseline	
	≥10 years	12	34.3	23	65.7	4.89	1.31–18.22	0.0180
Varicose veins		*16*	*21.2*	*58*	*78.8*			
Exercise	Every day + several times per week + free time	4	6.5	58	93.5	1	Baseline	
	Rare/never	12	21.4	44	78.6	4.33	1.21–15.33	0.0244
EOC	Continuous					1.35	1.13–1.61	0.0007
Allergic rhinitis		*20*	*17.2*	*96*	*82.8*			
Anxiety	Continuous					1.14	1.05–1.23	0.0009
EOC	Continuous					1.27	1.05–1.53	0.0141
Dermatitis		*21*	*18.3*	*94*	*81.7*			
Worksite	Cutting/packing	6	10.3	52	89.7	1	Baseline	
	Printing press	12	36.4	21	63.6	4.95	1.64–14.93	0.0045
	Color proofing/engraving/painting	3	12.5	21	87.5	1.24	0.28–5.42	0.7767
Skin allergy		*28*	*24.3*	*87*	*75.7*			
Toluene (exposure index)	<0.50§	15	17.6	70	82.4	1	Baseline	
	≥0.50	13	43.3	17	56.7	3.76	1.46–9.72	0.0062
Anxiety	Continuous					1.09	1.02–1.17	0.0130
Conjunctivitis		*22*	*20.6*	*85*	*79.4*			
Worksite	Cutting/packing/printing press/engraving	9	16.1	47	83.9	1	Baseline	
	Painting prep/color proofing	13	25.5	38	74.5	7.0	1.74–28.17	0.0062
Time in shiftwork	<10 years‖	9	13.6	57	86.4	1	Baseline	
	≤10 years	13	31.7	28	68.3	3.68	1.20–11.34	0.0230
Depression		*16*	*13.7*	*101*	*86.3*			
Time in shiftwork	<10 years‖	7	9.9	64	90.1	1	Baseline	
	≥10 years	9	19.6	37	80.4	0.23	0.06–0.85	0.0277
EOC	Continuous					1.45	1.19–1.76	0.0002
Cardiac arrhythmia		*7*	*5.7*	*116*	*94.3*			
Time in shiftwork	<15 years	2	2.1	93	97.9	1	Baseline	
	≥15	5	17.9	23	82.1	7.13	0.94–51.12	0.0507
Alcohol intake (per day)	<50.3 g‖	2	2.1	93	97.9	1	Baseline	
	≥50.3	5	17.9	23	82.1	6.74	1.10–41.50	0.0396
Gastritis		*19*	*16.8*	*94*	*83.2*			
Time in shiftwork	<10 years‖	6	8.6	64	91.4	1	Baseline	
	≥10 years	13	30.2	30	69.8	4.38	1.46–13.15	0.0084
EOC	Continuous					1.15	1.03–1.28	0.0124

* Individuals who developed the health conditions before working at the studied company were not included.
† Cut point is between percentiles 25 and 50.
‡ Cut point is percentile 75.
§ Cut point is the first tercile.
‖ Cut point is the second tercile.

skin allergy (OR, 3.76), another association that is widely recognized.[26] Toluene, ethyl acetate, and ethanol, especially a mixture of the three, pose higher health risks to exposed workers. Solvents are well known as potent agents causing local irritation on skin, eyes, and the respiratory system. They also present a systemic action by reaching the central nervous system and causing depression, headaches, sleepiness, and narcosis.[27]

Organizational factors such as shiftwork are significantly associated with gastritis, conjunctivitis, chronic back pain, and depression. Even though the etiology of these diseases is quite different, shiftwork may act as a triggering stressor and increase the risk of the diseases. One of the major complaints of shiftworkers is related to eating disorders and their consequences, eg, disturbances of

appetite, heartburn, gastritis, and peptic ulcers.[10] With regard to conjunctivitis, bad lighting (especially at night), efforts to keep awake during odd hours,[28–31] and touching eyes with dirty hands may play a role in causing the disease.

In the present study, the longer the time in shiftwork, the higher the likelihood of developing several diseases, with the exception of depression. Longer time in shiftwork was a protection factor for depression. This is probably attributable to the more effective coping strategies of those remaining in shiftwork. It is conceivable that those likely to suffer depression because of shiftwork may have left the job or been fired, and, consequently, were not included in the study.

Cardiac arrhythmia was found to be associated with shiftwork (OR, 7.13). Scandinavian studies have reported associations between cardiovascular diseases and shiftwork, with relative risks of about 1.5.[32–36] Although this reported relative risk of cardiovascular diseases is low, it has been argued that the prevalence in modern society is about 20%, which yields a population etiological fraction of 7%, making shiftwork an organizational factor that should be considered in the study of work-related cardiovascular disease.[37] The mechanism behind this effect is under investigation, but several hypotheses have been formulated and discussed elsewhere.[38] The difference in magnitude in the risk estimates from the Scandinavian studies and the present study may be attributable to differences in study design, exposures, individuals, or socioeconomic status between the populations that were studied.[39]

In the preliminary analysis, cardiac arrhythmia was associated with alcohol (above 50 g per day) and coffee consumption (7 to 8 small, 4-ounce cups per day) but with large confidence intervals (CIs) (alcohol consumption: 95% CI, 2.1 to 195.1; coffee: 95% CI, 1.2 to 234). When time in shiftwork was included in the logistic regression analysis, there was an association with cardiac arrhythmia (OR, 7.13; 95% CI, 0.94 to 51.12; $P = 0.05$), but only when coffee consumption was removed from the model. This suggests that time in shiftwork may play a role in the explanation of this disease.

It should be noted that the exposure levels for solvents in the company we studied were, in most instances, below internationally recommended limits, and that the mean age and tenure of the populations we studied were low (33 and 7.7 years, respectively). Several mechanisms by which solvents may precipitate cardiac arrhythmia have been explored and are presented and discussed in comprehensive review articles.[40,41]

The association between alcohol intake and cardiac arrhythmia observed in the present investigation is well known and is reported in both animal and human studies.[40] High intake of coffee and alcohol by shiftworkers is associated with several variables that mediate the risk of developing health problems, including those related to cardiovascular diseases. As reported in some studies, the characteristics of the shift schedules, the coping strategies needed to maintain alertness at work during the night hours and to fall asleep during the day, and the way workers spend their leisure time can have severe negative effects on health. Several of the studied shiftworkers usually spent their leisure time drinking beer and smoking, which can be negatively associated with health problems in this young population.

A recent publication[42] included several epidemiological studies about shiftwork and heart disease. The authors[39] suggested that many confounders were not appropriately controlled for and evaluated in previous studies that reported an association between cardiovascular disease and shiftwork. Nevertheless, the observed results in the current study showed that a population of printing workers exposed to combined occupational and non-occupational stressors had higher than average health risks.

Conclusions

The combined effects of environmental and organizational stressors at work presented important risk factors associated with diseases on the workers of the printing company studied. It is vital that a comprehensive approach be performed in studies of work life and its effects on workers' health. With such an approach, the complexities of the work environment and how it acts on the workers will allow a more complete understanding and efficient improvement of the work conditions. The findings of the present investigation (1) confirm the association between environmental and organizational factors and general health deterioration; and (2) indicate that without taking a multidimensional approach to preventing work-related disease, a healthy work life cannot be achieved.

Appendix: Sections of the Questionnaire for Study of the Effects of Combined Environmental and Organizational Stressors on Workers' Health

1. Demographic data (including job description).
2. Perception of shiftwork: sociofamilial relationships, health outcomes, reasons to work shifts.
3. Present perception of chemical stressors at the workplace: noise and solvents.
4. Descriptions of previous occupational and non-occupational exposures to noise and solvents.
5. Results of present noise and solvent exposures (environmental monitoring).
6. Perceived environmental and organizational conditions: floor levering, lighting, electrical installation, noise, odors, ventilation, thermal comfort, body posture, machine protection, fire hazards, pauses,

length of working day, cleanliness, quality of meals provided by the plant.

7. Perceived psychological stressors at work: work pace, emotional strain caused by the work environment and work tasks, the need to pay continuous attention to avoid mistakes, repetitive tasks.

8. Work control: influence over the planning of work, setting of the work pace, how time is used in work, selection of coworkers, work breaks, planning of vacations, flexible work hours, varied work content, varied work procedures, possibility of learning new tasks, experience of personal fulfillment on the job; workplace social support (possibility of talking to coworkers during breaks, leaving the job to talk with coworkers, interacting with coworkers as part of the work, and seeing and spending some hours with fellow workers or colleagues outside of work).

9. Perception of fear at work: fear of making mistakes, losing the job, suffering work accidents, having a work-related disease, dying because of a work-related accident or disease, being robbed on the way to or from work.

10. Anxiety symptoms: perspiration, tachycardia, diarrhea, tremors, worrying too much over something trivial, imagining terrifying scenes, can't keep anxiety-provoking pictures or thoughts out of mind, feeling tense in stomach, nervous pacing, losing out on opportunities because of delayed decision making, feeling physically immobilized, difficulties in concentrating because of uncontrollable thoughts.

11. Job characteristic measures (eg, job demands, work control, social support, fear at work).

12. General health and well-being (eg, physical and psychological health, satisfaction at work, anxiety).

13. Results of audiological tests

14. Medical history (including smoking habits and alcohol consumption).

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References

1. International Labour Organization/World Health Organization. *Recognition and Control of Adverse Psycho-Social Factors at Work*. Geneva: Joint ILO/WHO Committee on Occupational Health; 1984.
2. Karasek RA. Job demands, job decision latitude, and mental strain: implications for job redesign. *Adm Sci Q*. 1979;24: 285–307.
3. Kahn RA. *Work and Health*. New York: Wiley; 1981.
4. French JR, Caplan RD, Harrison RV. *The Mechanisms of Job Stress and Strain*. Chichester: Wiley; 1982.
5. Johnson JV, Johansson G, eds. *The Psychosocial Work Environment and Health: Work Organization, Democratization, and Health*. Amityville: Baywood; 1991.
6. Siegrist J. Adverse health effects of high-effort/low-reward conditions. *J Occup Health Psychol*. 1996;1:27–41.
7. Kalimo R. Assessment of occupational stress. In: Karvonen M, Mikheev MI, eds. *Epidemiology of Occupational Health*. vol 20. Geneva: World Health Organization, WHO Regional Publications, European Series; 1986:231–249.
8. Morata TC, Fiorini AC, Fischer FM, et al. Toluene-induced hearing loss among rotogravure printing workers. *Scand J Work Environ Health*. 1997;23:294–303.
9. Laurell MC, Noriega M. *Processo de Produção e Saúde. Trabalho e Desgaste Operário*. São Paulo: Hucitec; 1989.
10. Koller M. Health risks related to shiftwork. An example of time contingent effects on long-term stress. *Int Arch Occup Environ Health*. 1983;53:59–75.
11. Lundberg O, Manderbacka K. Assessing reliability of a measure of self-rated health. *Scand J Soc Med*. 1996;24:218–224.
12. Thiele H, Enderlein G. Cross-sectional studies. In: Karvonen M, Mikveev MI, eds. *Epidemiology of Occupational Health*. Geneva: World Health Organization, WHO Regional Publications, European Series;1986: 135–148.
13. National Institute for Occupational Safety and Health. In: Eller PM, ed. *Manual of Analytical Methods*. 4th ed. Cincinnati: NIOSH; 1994. DHHS/NIOSH pub. no. 94–113.
14. American Conference of Governmental Industrial Hygienists. *Threshold Limit Values and Biological Exposure Indices for 1995–1996*. Cincinnati: ACGIH; 1995.
15. Brasil. Ministério do Trabalho, Secretaria de Segurança, Higiene e Medicina do Trabalho. Segurança e Medicina do Trabalho Lei n. 6514, de 22 de dezembro de 1977. *Norma Regulamentadora (NR) Aprovadas Pela Portaria 3214 de 8/6/1978*. São Paulo: Ed. Atlas; 1996:NR-15, Anexo 11.
16. Rohmert W, Landau K. *A New Technique for Job Analysis*. London: Taylor & Francis; 1983.
17. Barton J, Folkard S, Smith LR, Spelten ER, Totterdell PA. *Standard Shiftwork Index Manual, MRC/ESRC Social and Applied Psychology Unit*. Sheffield: SAPU; 1991. Memo 1159.
18. Kundi M, Koller M, Stefan H, Lehner L, Kaindlsdorfer S, Rottenbücher S. Attitudes of nurses towards 8-h and 12-h shift systems. *Work Stress*. 1995;9:134–139.
19. Fischer FM, Paraguay AIBB, Bruni AC, et al. Working conditions, work organization and consequences on health of Brazilian petrochemical shiftworkers. *Int J Ind Erg*. 1998;21:209–219.
20. Johnson JV, Stewart W, Fredlund P, Hall EM, Theorell T. *Psychosocial Job Exposure Matrix: An Occupationally Aggregated Attribution System for Work Environment Exposure Characteristics*. Stockholm: National Institute for Psychosocial Factors and Health, Department of Stress Research, WHO Psychosocial Centre; 1990. Stress Research Reports (221).
21. Hosmer DW Jr, Lemeshow S. *Applied Logistic Regression*. New York: Wiley and Sons; 1989:56–58.
22. Krause N, Lynch J, Kaplan GA, Cohen RD, Goldberg DE, Salonen JT. Predictors of disability retirement. *Scand J Work Environ Health*. 1997;23:403–413.
23. Cacioppo JT, Tassinary LG. Inferring psychological significance from physiological signals. *Am Psychol*. 1990;45:16–28.
24. Burdorf A, Sorock G. Positive and negative evidence of risk factors for back disorders. *Scand J Work Environ Health*. 1997;23:243–256.
25. Bongers PM, de Winter CR, Kompier MA, Hildebrandt VH. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health*. 1993;19: 297–312.
26. Andrews LS, Snyder R. Toxic effects of solvents and vapors. In: Klaasen CD, Amdur MO, Doull J, eds. *Casarett and Doullis Toxicology: The Basic Science of Poisons*. 3rd ed. New York: MacMillan; 1985.
27. National Institute for Occupational Safety and Health. *Recommendations for Control of Occupational Safety and Health Hazards. Manufacture of Paint and Allied Coating Products*. Cincinnati: NIOSH; 1984. US pub. no.84–115.
28. Åkerstedt T. Work schedules and sleep. *Experientia*. 1984;40:417–422.
29. Åkerstedt T. Shifted sleep hours. *Ann Clin Res*. 1985;17:273–279.

30. Åkerstedt T. Work hours and sleepiness. *Neurophysiol Clin*. 1995;25:367–375.
31. Harma M, Tenkanen L, Sjoblom T, Alikoski T, Heinsalmi P. Combined effects of shift work and life-style on the prevalence of insomnia, sleep deprivation and daytime sleepiness. *Scand J Work Environ Health*. 1998;24:300–307.
32. Åkerstedt T, Knutsson A, Alfredsson L, Theorell T. Shift work and cardiovascular disease. *Scand J Work Environ Health*. 1984;10(6 spec no):409–414.
33. Knutsson A, Akerstedt T, Jonsson BG, Orth-Gomer K. Increased risk of ischaemic heart disease in shift workers. *Lancet*. 1986;2(8498):89–92.
34. Tuchsen F. Working hours and ischaemic heart disease in Danish men: a 4-year cohort study of hospitalization. *Int J Epidemiol*. 1993;22:215–221.
35. Kawachi I, Colditz GA, Stampfer MJ, et al. Prospective study of shift work and risk of coronary heart disease in women. *Circulation*. 1995;92:3178–3182.
36. Tenkanen L, Sjoblom T, Kalimo R, Alikoski T, Harma M. Shift work, occupation and coronary heart disease over 6 years of follow-up in the Helsinki Heart Study. *Scand J Work Environ Health*. 1997;23:257–265.
37. Kristersen TS. Cardiovascular diseases and the work environment. *Scand J Work Environ Health*. 1989;15:165–179.
38. Åkerstedt T, Knutsson A. Cardiovascular disease and shift work. *Scand J Work Environ Health*. 1997;23:241–242.
39. Boggild H, Knutsson A. Shift work, risk factors and cardiovascular disease. *Scand J Work Environ Health*. 1999;25:85–99.
40. Zakhari S, Salem H. Cardiac toxicology of solvents. In: Baskin S, ed. *Principles of Cardiac Toxicology*. Boca Raton: CRC Press; 1991.
41. Piano MR, Schwertz DW. Alcoholic heart disease: a review. *Heart Lung*. 1994;23:3–17.
42. Boggild H. *Shift Work and Heart Disease. Epidemiological and Risk Factor Aspects* [PhD thesis]. Aalborg: Centre for Working Time Research, Department of Occupational Medicine, Aalborg Regional Hospital, and Faculty of Health Sciences, University of Aarhus; 2000.

Why Do Ships Register in Liberia?

We are fine with wearing clothes made in China, drinking wine from Chile, and watching movies shot in Toronto. But one piece of international cross-pollination baffles us: Why are so many ships registered in Liberia?

Look closely at the fine print on any cruise brochure, and you are likely to find mention of Liberia, located on the northwest coast of Africa. Ships are registered overseas to save boatloads of money, says one cruise official, speaking on the condition of anonymity. For a ship to fly the Stars and Stripes, it must be owned and crewed by Americans, making it subject to US labor laws, including the minimum wage. American ships also must hire from costly labor unions.

So why Liberia specifically? Because the Liberian ship registry—set up by US shippers after World War II—is cheaper than nearly any other in the world . . . Liberia, founded by freed American slaves, has always enjoyed a close trading relationship with the United States. Today its merchant marine is one of the world's largest. Liberia's ensign rivals even Panama's, among so-called flags of convenience.

—Tucker R. Why do ships register in Liberia? *Fortune*. 2001;143(12):42.