palpitation among pathology residents and exposure to fluorocarbons in the preparation of frozen sections from surgical specimens.[244] A negative study involved ambulatory EKG monitoring and exposure measurements to fluorocarbon-113 in sixteen sedentary aerospace workers. The frequency of ventricular and atrial premature beats and other evidence of dysrhythmias on a low exposure day (64 ppm personal time-weighted average [TWA]) were compared to a higher exposure day (442 ppm TWA).[62] There is also an equivocal study among refrigerator repairmen.[61]

In summary, occupational exposures to fluorocarbon-113 at levels below the OSHA standard of 1000 ppm have not been associated with cardiac dysrhythmias.

Several epidemiologic mortality studies of solvent-exposed workers have been conducted, principally in aerospace, rubber, chemical, and dry cleaning industries. Each of these studies has limitations in determining if there is an association between acute solvent exposure and cardiac mortality. Most were designed to concentrate on the relationship between chronic solvent exposure and cancer rather than acute exposure and CVD. The majority of cardiac deaths occurred years after exposure ceased. Most did not have detailed exposure measurements; therefore, the potential for misclassification of exposure is substantial. A review of the epidemiologic literature shows no *consistent* association between solvents, with the exception of CS_2, and elevated risks of mortality from heart disease.[286]

A few studies do indicate one or more positive associations. A case-control study in the rubber industry found no evidence of association between the most solvent exposures and heart disease, but did find limited evidence of an association between ethanol or phenol exposure and mortality from CAD.[287] A recent cross-sectional study reported associations between occupational exposures to benzene or xylene, but not to phenol, and the prevalence of hypertension, atrial, and ventricular ectopic beats.[142] A significant but slight increase in mortality from CAD was reported among aerospace workers exposed to trichloroethylene or toluene.[22] This study had an internal reference group and careful exposure assessment. The 10–20% increases in this study generally were not dose related, and there were overlapping exposures to several solvents. In another study of trichloroethylene there was no evidence of an increased risk from CV mortality in the workers with long duration or higher levels of exposure.[13]

PSYCHOSOCIAL FACTORS: REVIEW OF THE EMPIRICAL DATA AMONG MEN *by Karen Belkić, MD, PhD, Paul Landsbergis, PhD, Peter Schnall, MD, Dean Baker, MD, Töres Theorell, MD, PhD, Johannes Siegrist, PhD, Richard Peter, PhD, and Robert Karasek, PhD*

In 1958, a case-control study by Russek and Zohman revealed that of 97 male coronary patients under age 40, 91% were judged to have been exposed to "occupational stress and strain," based on a detailed occupational history, compared to 20% of healthy controls.[224] In the same year, Friedman, Rosenman and Carroll published their seminal paper demonstrating a significant relation between serum cholesterol and blood clotting times, and cyclic variation in occupational stress among accountants.[76] Since these early studies there has been a burgeoning body of evidence demonstrating a relationship between psychosocial factors at the workplace and cardiovascular disease (CVD).

Approximately 20 years ago, the **Job Strain Model** was introduced by Karasek.[123] Systematic investigation of psychosocial workplace factors and CVD was dramatically advanced by this model, which can be readily applied in epidemiologic studies. The first hypothesis is that strain occurs when there is excessive psychological

workload demands together with low job decision latitude. This combination provokes arousal, as well as distress, activating both the sympathoadrenomedullary and adrenocortical axes, and yielding a highly deleterious combination.[71,74] A third dimension, social isolation, was later added to the Job Strain Model.[114] The second hypothesis is that high demands together with high decision latitude lead to active learning of new behaviors, and possibly improved health through long-term positive changes in coping behaviors. (See Chapter 3 for a detailed discussion of the theoretical construct.)

More recently, the **Effort-Reward Imbalance (ERI) Model** was introduced by Siegrist and colleagues.[233–235] In comparison to the Job Strain Model with its emphasis on moment-to-moment control over the work process (i.e., decision latitude), the ERI Model provides an expanded concept of control, emphasizing macro-level long-term control vis-à-vis rewards such as career opportunities, job security, esteem, and income. The ERI Model assesses the balance between these rewards and effort, positing that work stress results from an imbalance between high effort and low control over long-term rewards. Effort is seen to stem both extrinsically from the demands of the job and intrinsically from the individual's tendency to be overly committed to these work demands. (See Chapter 3 for further discussion.) In addition to research using these two models, several other psychosocial risk factors are being examined for their potential explanatory value with regard to CV outcomes. Threat-avoidant vigilant work, also termed "disaster potential," represents a plausible construct for which there is some empirical data, reviewed herein.

The following review results from *in extenso* English language publications in peer-reviewed journals as these pertain to samples of men, in whom the majority of this research has been conducted. The empirical evidence with regard to workplace psychosocial factors and CVD outcomes among women is described toward the end of this chapter.

The Job Strain Model

ISCHEMIC HEART DISEASE AND OTHER HARD CVD ENDPOINTS

Table 3 presents the data concerning exposure to job strain and/or its major dimensions, in relation to ischemic heart disease or other hard CVD endpoints. A brief description of how the job strain variable was assessed in each study, the variables for which adjustment is made, and significant positive as well as null and negative findings are shown. (For more details concerning methods for evaluating job strain and other psychosocial workplace factors, see Chapter 6.)

There were eight case-control studies of job strain and CVD. Those investigations which obviated self-report bias by imputing job strain exposure on the basis of occupational title revealed major significant findings with regard to aspects of control[6,8,87,265] and/or to exposure to high psychological demands together with low control.[6,8,88] The other five studies, relying on self-report data, also revealed primarily significant positive associations. An exception is the very small study of Emdad, et al., which, unlike the others, restricted itself to a single occupational group (professional drivers) having a limited range of variation on demands and control, and, thus, less statistical power to detect an effect of job strain.[64]

Self-report data of Hallqvist, et al. provided another important facet of causal evidence by showing a dose-response relationship between strength of exposure to job strain and relative risk of myocardial infarction.[87] The significant, positive Synergy Index reveals that exposure to the combination of high demands and low control confers greater risk than the additive effects of the dimensions.

TABLE 3. Studies of Job Strain and Ischemic Heart Disease among Men

Case Control Studies

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Alfredsson, et al. (1982 & 1983)	Swedish, < 65 y.o. N = 334 cases, N = 882 population controls	Imputed: Hectic/various aspects of control as quadrant terms	Hospitalized and/or fatal MI	Total study *(Age)* Monotony Rushed tempo + low influence over work tempo Rushed tempo + not learning new things 40–54 y.o. *(Age & immigrant status or education)* Hectic work + no influence on pace Hectic work + few possibilities to learn new things	RR 1.32 1.35 1.45 ≈ 1.7 ≈ 2	Rushed tempo = NS Low influence over work tempo = NS Not learning new things = NS Rushed tempo + monotony = NS *(Age)*
Billing, et al. (1997)	Swedish, < 70 y.o. Cases: N = 531 male, 236 female Population controls: N = 34 male, 15 female	Self-report: PSJSQ Main effects only	Chronic, stable angina pectoris, clinic patients	Skill discretion Control *(Age)*	p < .001 < .01	ψ demand = NS Decision authority = NS *(Age)*
Bobák, et al. (1998)	Czech, 25–64 y.o. N = 179 cases N = 784 controls All full-time employed	Self-report: ψ Demands (3 items) Decision-latitude (8 items) Quartile term (21% job strain)	First nonfatal MI	Highest decision latitude quartile *(Age, district, education, hypertension, other coronary RF)*	RR 0.43	Job strain = NS Highest ψ demands quartile RR = 0.52 *(Age, district, education, hypertension, other coronary RF)*
Emdad, et al. (1997)	Swedish, < 52 y.o. N = 13 cases N = 12 hypertensive controls, All professional drivers	Self-report: PSJSQ Demand/control Quotient term	Hospitalized IHD			Job strain = NS ψ demand = NS Decision latitude = NS Skill discretion = NS Control = NS *(Age)*

(Table continued on next page.)

TABLE 3. Studies of Job Strain and Ischemic Heart Disease among Men *(Continued)*

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*	*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Hallqvist, et al. (1998), Theorell, et al. 1998)	Swedish, 45–64 y.o. N = 1047 cases N = 1450 population controls	Self-report: PSJSQ Quartile term and optimal term (reflects optimum balance between exposure contrast and power) Imputed: PSJEM Decision latitude Quartiles	First hospitalized and/or fatal MI	(Quartile) RR (Optimal) RR Self-report: Job strain 2.2 → 9.2 Synergy index 4.0 → 7.5 • Manual workers Job strain 10.0 → 46.1 Synergy index 11.1 → 23.9 Decision latitude 2.3 *(Hypertension, smoking, BMI)* Imputed RR Decision latitude *(Age, catchment area)* 1.7	Self-report: • Non-manual workers Job strain = NS ψ demands = NS Decision latitude = NS • Manual workers ψ demands = NS *(Hypertension, smoking, BMI)* Imputed Decision latitude = NS *(Age, catchment area, social class, coronary RF)*
Hammar, et al. (1994)	Swedish, 30–64 y.o. N = 13,205 cases N = 22,599 population controls	Imputed: Hectic/aspects of Decision-latitude Quadrant term (relaxed quadrant as referent)	First MI	White collar RR Hectic work and low influence over work hours 1.4 *(Age, county, calendar year)*	Blue collar Single factors = NS Hectic work and other factors = NS White collar Single factors = NS *(Age, county, calendar year)*
Sihm, et al. (1991)	Danish, < 55 y.o. N = 52 cases N = 72 community and hospital controls	Self-report: Workload/elements of control Quadrant term	Survivors of MI	RR Heavy workload + contradictory demands 1.96 Heavy workload + low responsibility 1.78 Low workload + good social interaction 0.58 *(Age, SES)*	Workload = NS Autonomy = NS Influence = NS Contradictory demands = NS Growth + development = NS *(Age, SES)*
Theorell, et al. (1987)	Swedish, < 45 y.o. N = 85 cases N = 116 community controls	Self-report: 3 Quotient terms: Demands (2 items) ÷ Influence (3 items) Intellectual discretion or variety (1 item each)	Hospitalized nonfatal MI Coronary artery atheromatosis	p Variety of work tasks 0.01 ψ demands/variety of work tasks 0.01 ψ demands/intellectual discretion 0.04 *(Age, education, coronary risk factors)*	ψ demands = NS Influence over work = NS Intellectual discretion = NS ψ demands/influence over work = NS *(Age education, coronary risk factors)* Degree coronary atheromatosis and quotient terms or main effects = NS

(Table continued on next page.)

TABLE 3. Studies of Job Strain and Ischemic Heart Disease among Men *(Continued)*

Cross Sectional Studies

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Johnson, et al. (1988)	N = 7165, Swedish, 16-65 y.o. population sample	Self-report: ψ Demands (2 items) Control (11 items) Support (5 items) Quadrant term (relaxed quadrant as referent)	Self-reported CVD (N = 409)	Blue collar High ψ demands/low control High ψ demands/low control/ low support White collar High ψ demands/low support *(Age, dimensions of isostrain)* 3-Factor multiplicative interaction ratio = 1.09	PR 3.55 7.22 1.81	All High ψ demands = NS Control = NS White collar High ψ demands/low control = NS *(Age, dimensions of isostrain)*
Johnson, et al. (1989)	N = 7219, Swedish, 25-65 y.o. population sample	Self-report: ψ Demands (2 items) Control (11 items) Support (5 items) Compare high to low quintile	Self-reported CVD (N = 407)	All Isostrain Blue collar Isostrain *(Age)*	PR 1.77 2.04	White collar Isostrain *(Age)* = NS
Karasek, et al. (1987)	N = 5000, Swedish, mean age 37.1 ± 12.1, white collar, trade-union members	Self-report: Workload (3 items) Decision latitude (4 items) Main effects only	Self-reported heart disease	*(Age, marital status)* Workload Conflict Clarity Decision/latitude Social support	SQR 1.24 1.18 1.12 0.92 0.90	
Karasek, et al. (1988)	U.S., 18–79 y.o. N = 2409 HES, N = 2424 HANES population sample (87% white)	Imputed: QES Quadrant term (20% job strain)	MI (N = 39 HES) (N = 30 HANES)	Job strain—HES —HANES ψ Demands—HANES Decision latitude—HES —HANES *(Age, race, education, SBP, other coronary RF)*	SQR 1.5 1.6 2.1 −1.5 −2.0	ψ Demands—HES = NS *(Age, race, education, SBP, other coronary RF)*

(Table continued on next page.)

TABLE 3. Studies of Job Strain and Ischemic Heart Disease among Men *(Continued)*

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*	*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Hlatky, et al. (1995)	N = 1132 males, N = 357 females U.S. patients undergoing coronary angiography (88% white, 60% white collar)	Self-report: JCQ Predefined cutpoints: (23% job strain men, 43% in women) Job strain index = quotient	Degree of coronary atheromatosis		Job strain = Quadrant term = NS Index = NS *(Age, gender, blood pressure, coronary risk factors, history of MI, typical angina)*

Cohort Studies

First Author (Year)	*Study Participants*	*F/u (y)*	*Form(s) of Job Strain Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounder)*		*Null or Sig. Negative Assoc. (Adjusted Confounder)*
Alfredsson, et al. (1985)	N = 958,096 total*, Swedish, 20–64 y.o., population-based	1	Imputed: Hectic/various aspects of control as quadrant terms	Hospitalized MI (N = 1059)	*(Age)* Punctuality Few possibilities to learn new things Hectic and monotonous work Hectic work and few possibilities to learn new things *(Age + marital status, nationality, income, smoking* or *heavy lifting at work)*	SMR 121 113 118 ≈ 125	*(Age)* Hectic work = NS Monotonous work = NS
* Total not by gender, gender-stratified analysis done—males in this table							
Bosma, et al. (1997 & 1998)	N = 6896, U.K., 35–55 y.o. civil servants	5.3	Self-report: ψ Demands (4 items) Control (15 items) Median cutpoint quadrant Term and interaction term Observer: 4 items	Self-report Angina, CHD event, Dx. IHD	*(Age & f/u time)* Low control (SR) & angina pectoris Low control (SR) & diagnosed IHD Low control (SR) & any CHD event Low control (O) & any CHD event Job strain (SR) & any CHD event	OR 1.54 1.6 1.55 1.43 1.45	Job strain (SR) & angina pectoris = NS Job strain (SR) & diagnosed IHD = NS Job strain (O) & all outcomes = NS *(Age &f/u time)*
Johnson, et al. (1989)	N = 7219, Swedish, 25–65 y.o. population-based	9	Self-report: ψ Demands (2 items) Control (11 items) Support (5 items) Compare high to low quintile	CVD mortality (N = 193)	*(Age)* Isostrain: Total group Blue collar	RR 1.92 2.58	Isostrain: White collar = NS *(Age)*

(Table continued on next page.)

TABLE 3. Studies of Job Strain and Ischemic Heart Disease among Men *(Continued)*

First Author (Year)	*Study Participants*	*F/u (y)*	*Form(s) of Job Strain Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sign. Negative Assoc. (Adjusted confounders)*
Johnson, et al. (1996)	N = 12,517, Swedish 25–74 y.o. population-based (nested case-control N = 2422 controls)	14	Imputed: ψ Demands (2 items) Control (12 items) Support (4 items) Interaction terms	CVD mortality (N = 521)	Low control Low control/low support *(Age, class, nationality, physical job demands, education, exercise, smoking, last year employed)*	RR 1.83 2.62	ψ demands = NS Job strain = NS *(Same adjustment as for positive findings)*
Karasek,et al. (1981)	N = 1461, Swedish, 15–61 y.o., population-based (Nested* case-control: N = 66 controls)	9	Self-report: ψ demands (2 items) Intellectual Discretion (2 items) Personal Schedule Freedom (3 items)	CVD & cerebro-vascular mortality (N = 22)	High ψ demands High ψ demands & low personal freedom schedule *(Age, education, smoking, CHD sx at baseline)*	OR 4.0 4.0	Low intellectual discretion = NS Low personal freedom schedule = NS *(Same adjustment as for positive findings)*
		6		Self-report CHD	High ψ demands Low Intellectual Discretion *(Age, education, smoking, overweight)*	SQR 1.29 1.44	Personal Schedule Freedom = NS *(same adjustment as for positive findings)*
Theorell, et al. (1991a)	N = 79, Swedish, < 45 y.o. employed, first MI survivors	5	Self-report: 3 Quotient terms: Demands (2 items) ÷ Influence (3 items), Intellectual discretion or variety (1 item each)	Mortality from repeat MI (N = 13)	Demands + variety (univariate) Demands + intellectual discretion *(Biomedical risk factors)*	P 0.03 0.02	Demands = NS Single aspects of decision latitude = NS
Alterman, et al. (1994)	N = 1683 U.S., 38–56 y.o. Chicago Western Electric healthy employees of European ancestry (74% blue collar)	25	Imputed: QES Tertile term (7% job strain))	CHD mortality	High decision latitude *(Age, SBP, cholesterol, smoking, alcohol, family history CVD)*	RR 0.76	Job strain *(Age)* = NS ψ Demands *(Age)* = NS Decision latitude *(Education + age, SBP, cholesterol, smoking, alcohol, family history CVD)* = NS

(Table continued on next page.)

TABLE 3. Studies of Job Strain and Ischemic Heart Disease among Men *(Continued)*

First Author (Year)	*Study Participants*	*F/u (y)*	*Form(s) of Job Strain Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Hlatky, et al. (1995)	N = 1132 men, N =357 women U.S. patients undergoing coronary angiography (88% white, 60% white collar)	4	Self-report: JCQ (Cutpoints: ψ demands > 32, decision latitude < 28) Men: 23% job strain Women: 43% job strain Job strain index = quotient term	Incident nonfatal MI (N = 70) Cardiac deaths (N = 42)			In patients with significant CAD: Job strain index & quadrant term = NS for cardiac death & cardiac events *("Established prognostic factors" including ejection fraction, CAD extent, myocardial ischemia)* In patients without significant CAD: Job strain index & quadrant term = NS for cardiac events (N = 6 total) *(Age, gender, ejection fraction, insignificant CAD)*
Reed, et al. (1989)	N = 4737, U.S. Hawaiians of Japanese descent, 45–65 y.o. population-based	18	Imputed: QES Quartile Term Multiplicative Score Vector Score	Incident definite CHD (N = 359)			All calculated forms of Job Strain = NS ψ Demands = NS Decision latitude = NS In acculturated group: Low job strain (vector score) $p < 0.05$ *(Age, blood pressure & other coronary risk factors)*
Steenland, et al. (1997)	N = 3575, U.S. 25–74 y.o., population-based 58% blue collar	12–16	Imputed: QES Quartile term (17% job strain)	Incident heart disease (N = 519)	Job control (highest compared to lowest quartile) *(Age, education, blood pressure, other coronary risk factors)*	OR 0.71	Stratified analysis blue and white collar: Job strain, ψ Demands, Low control = NS High control & high demand OR = 0.69 for blue collar *(As for positive findings)*

ψ = psychological, Dx = diagnosed, HES = Health Examination Survey, HANES = Health and Nutrition Examination Survey, IHD = ischemic heart disease, JCQ = job content questionnaire, NS = nonsignificant, OR = odds ratio, PSJSQ = psychological job strain questionnaire (Swedish), PSJEM = Psychosocial Job Exposure Matrix, QES = quality of employment surveys, RF = risk factors, RH = relative hazard, RR = relative risk, SES = socioeconomic status, SMR = standard mortality ratio, SR = self-reported.

Notes: Significant positive associations require a lower limit of the 95% confidence intervals > 1.0 and/or $p < 0.05$. The N for women is indicated only if the analysis was *not* gender stratified.
*The study by Karasek, et al. (1981) analyzes incident cases of CVD death compared to matched controls selected from the cohort. As per Hulley, et al.,[109] we term this a "nested case control study" and include it within the cohort studies.

Of the five cross-sectional investigations of job strain and CVD, four relied upon self-report of exposure to the job strain dimensions and of the disease outcome. Johnson and Hall found that the interaction among demand, control, and support was more than multiplicative (by 9%), with a three-factor multiplicative interaction ratio = 1.09.[114] Karasek, et al. used the imputational method to assess exposure to job strain, together with objective verification of the presence of myocardial infarction (MI).[124] Thus, this population-based, cross-sectional data can be considered free of self-report bias of any kind and reveals a significant positive association between exposure to job strain, as well as each of its main dimensions, and MI.

Among the ten cohort studies of job strain and CVD, six report significant positive results with regard to exposure to various types of low control,[7,9,29,30,116,247] and four show significant associations with exposure to some form of high psychological demands coupled with low control.[7,29,30,119,259a] Significant positive results were seen for exposure to high psychological demands alone[119] and for isostrain (high psychological demands, low control and low social support at work).[115]

Four cohort studies had predominantly null results.[9,103,218,247] Three of these had followup periods of 12–25 years without assessment of employment status subsequent to intake, such that the participants were likely to have been temporally far removed from these job exposures.[9,218,247] In two of these the mean age at CHD occurrence is high, and with advancing age the impact of CVD risk factors declines.[9,218] The three also used the imputation method for determining exposure to job strain (see Chapter 6). While providing a convenient means of converting coded occupational titles into exposure data and obviating self-report bias, the imputation method provides no assessment of within-occupation variability and, due to nondifferential misclassification, underestimates actual associations between job characteristics and health outcomes.[143] Thus, while significant positive associations found using the imputational method provide powerful evidence for the model, negative or nonconfirmatory studies may be due, at least in part, to loss of statistical power.[226] This is particularly problematic with respect to psychological demands, which show the largest amount of variance within rather than between occupations, and this variance is therefore not reflected in the averaged values.[261]

Particular attention in the clinical cardiologic arena has been paid to the study of Hlatky and colleagues in which exposure to job strain was reported not to be significantly associated cross-sectionally with degree of angiographically-assessed coronary atherosclerosis, nor prospectively with cardiac events.[103] In immediate response to the publication of these results, the American Heart Association issued the following statement: "Although psychological stress in the workplace is widely believed to increase the risk of coronary heart disease, scientific evidence supporting this belief 'is relatively sparse' according to scientists publishing a new study. Their research suggests that job strain is not an important coronary risk factor."[10] We believe that this conclusion is incorrect. This study does not appear to have been designed initially to test the job strain hypothesis. The original purpose of this research seems to have been to examine employment patterns among patients with coronary artery disease.[168] The sampling technique used (evaluation of all patients with chest pain undergoing coronary angiography) may have been suitable to that purpose. However, it is not appropriate for research intended to explore the role of psychosocial stress factors in CVD.

A close examination of the study reveals a number of major, interconnected flaws which inextricably undermine its internal validity. By choosing consecutive stable patients with chest pain, who were undergoing coronary angiography at a university hospital, as the study sample, with the cross-sectional endpoint being degree

of coronary atherosclerosis, the chances are high that the etiologic relationship between exposure and outcome is severely distorted.[109,215] This overreporting of chest pain would lead a large number of patients without coronary artery disease (CAD), but *with* self-reported job strain, to present to the medical system, and insofar as a substantial number of these persons were sent to angiography, this would lead to a lowered odds ratio for CAD related to job strain. This form of **selection bias** is an example of *differential* misclassification, which tends to bias the results negatively. Existing effects between job strain and CAD are less likely to be detected because the frequency of reported chest pain is higher, by at least an order of magnitude,[219] in the study patients than in the population of a similar age.

Patients with chest pain and normal coronary arteries have been recognized as a group with a high prevalence of occupational and behavioral difficulties.[42,154,195,200,206,208] Major problems with confounding also exist in the Hlatky, et al. study. The patients with normal coronary arteries or insignificant CAD more often had white-collar jobs than did the patients with significant CAD ($p = 0.0001$), and yet no adjustment for socioeconomic status was made. Lack of gender stratification further obfuscates etiologic relations. By self-report data, 43% of the women fell into the job strain category compared to 23% of the men. Women comprised 48% of patients with normal coronary arteries versus 14% of those with significant CAD. No mention was made of Syndrome X, characterized by enhanced ventricular pain sensitivity,[199] and whose prevalence among women is high.[282] There is also evidence that the CAD patients reporting low decision-latitude and/or job strain had disproportionately stopped working at 1 year followup[168]; this further attenuates any association between point exposure to job strain at entry into the study and subsequent cardiac events.

One cohort study examined the important issue of cumulative exposure to psychological demands, control, and social support.[116] These authors emphasize that the etiological fraction for CV disease mortality attributable to long-term exposure to low work control is substantially larger (35%) than previously estimated for job strain assessed at a single point in time (7–16%). By assessing cumulative exposure it becomes apparent that the magnitude of the CV effects due to unhealthy work conditions has been heretofore largely *underestimated*.

These studies, taken together, predominantly demonstrate a significant, positive relation between exposure to low control and/or job strain and subsequent CVD. The evidence, while limited, suggests the existence of a dose-response relationship (both in terms of intensity of point exposure[87] and temporal duration[116]) between exposure to job strain or low control and CVD outcomes. The cohort studies provide another important piece of confirmatory evidence of causality, based upon their demonstration that the temporal nature of the association is in the expected direction.

BLOOD PRESSURE

Ambulatory Blood Pressure Studies. As elaborated in Chapter 5, there are numerous potential mediating mechanisms by which psychosocial workplace factors can increase the risk of developing ischemic heart disease. Elevation in arterial blood pressure (BP) and hypertension represent one of the most well-recognized and important risk factors, with ambulatory, as opposed to casual, clinic BPs being of greatest prognostic importance, particularly when recorded during work.

Table 4 summarizes the data relating job strain and/or its major dimensions to ambulatory BP. Of the 11 cross-sectional ambulatory BP studies, five reveal a significant positive effect of exposure to job strain upon ambulatory systolic blood pressure (SBP) recorded during work.[41,159,227,228a,276] In the four of these five studies in

TABLE 4. Studies of Job Strain and Ambulatory Blood Pressure among Men

Cross-Sectional Studies

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Significant Positive Effects: SBP (Adjusted Confounders)*	*Significant Positive Effects: DBP (Adjusted Confounders)*	*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Blumenthal, et al. (1995)	N = 61, U.S., 29–59 y.o. mild, unmedicated hypertensives	Self-report: JCQ Quadrant term (24% job strain) (% men not specified)			–4 SBP (significance unspecified) DBP = NS *(Age, education, income, job status)*
Cesana, et al. (1996)	N = 527, No. Italian, 25–64 y.o. population sample	Self-report: JCQ Quadrant and tertile terms	Quadrant Tertile Normotensives: Work +3.4 –› +4.2 24 h +2.8 –› +4 *(Age, education, overwt index, PA)*		Borderline hypertensives Quadrant term work and 24 h: SBP and DBP = NS Tertile term: SBP work: –4.6, 24h: –3 DBP work: –1.7, 24h: –1 Normotensives Quadrant and tertile term: Work & 24 h DBP = NS *(As SBP)*
Härenstam, et al. (1988)	N = 66, Swedish, (age unspecified), prison staff	Self-report: Job demands (14 items) Decision-latitude (2 items) Skill discretion (6 items) Main effects only	Skill discretion predicts Work SBP $p < 0.01$ Leisure SBP $p < 0.001$ *(Age, status, nightwork, ETOH, BMI)*		
Knox, et al. (1985), Theorell, et al. (1985)	N = 71, Swedish, 26–32 y.o. from military recruit lists	Imputation: Hectic (1 item) Control over work pace (1 item) Quadrant term (28% job strain)			SBP: Work and home = NS DBP: Work and home = NS
Light, et al. (1992)	N = 65, U.S., 18–47 y.o. 58% white, 42% black 71% white collar	Self-report: JCQ Quadrant term (23% job strain-men)	Job strain: Work + 6.0 *(Age, BMI, status, PA, posture, race)*	Job strain: Work + 4.0 *(As SBP)*	ψ demand, decision latitude, skill discretion work SBP + DBP = NS *(As SBP)*

(Table continued on next page.)

TABLE 4. Studies of Job Strain and Ambulatory Blood Pressure among Men *(Continued)*

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Significant Positive Effects: SBP (Adjusted Confounders)*	*Significant Positive Effects: DBP (Adjusted Confounders)*	*Null or Sig. Negative Assoc (Adjusted Confounders)*
Schnall, et al. (1992), Landsbergis, et al. (1994)	N = 262, U.S., 30-60 y.o. from 8 worksites, 84% white	Self report: JCQ Quadrant term (21% job strain) and 9th cell term	Job strain Quadrant 9th cell Work +6.7 → +11.5 Home +6.5 → +8.6 Sleep +6.2 (no data) ψ demands Work (p = 0.015) *(Age, race, education, BMI, smoking, PA, urine Na*, TAB, worksite, ETOH)*	Job strain Quadrant 9th cell Work +2.7 → +4.1 *(As SBP)*	Job strain: DBP home & sleep = NS ψ demands = NS (except work SBP) Decision latitude = NS *(As SBP)*
Schnall, et al. (1998)	N = 195, U.S., 33–63 y.o. from 8 worksites, 84% white	Self-report: JCQ Quadrant term (16% job strain)	Job strain Work +6.4 Home +6.9 Sleep +5.0 *(Age, race, BMI, smoking, ETOH)*	Job strain Work +5.0 Home +4.9 *(As SBP)*	Job strain sleep DBP = NS *(As SBP)*
Steptoe, et al. (1995)	N = 49, U.K., 20–29 y.o. firefighters	Self-report: ψ demands (3 items) Control (3 items) Skill utilization (4 items) (51% job strain)	Job strain & systolic reactor: Afternoon work +12.4 *(Groups with and without job strain, high-low reactivity did not differ significantly in age, BMI, ETOH, smoking, baseline BP, inter alia)*		Job strain: Work SBP & DBP = NS
Steptoe, et al. (1999)	N = 60 men, N = 102 women* UK, mean age = 39 teachers	Self-report: 10 items/quotient term with cutpoints (49% job strain total) (% in men unspecified)	Low job strain: Evening work +3.1 *(Age, BMI, baseline SBP)*	Low job strain Evening work +2.1 *(Age, BMI)*	Job strain: Work SBP & DBP = NS Evening SBP & DBP = NS *(Age,BMI)*
Theorell, et al. (1991b)	N = 161, Swedish, 35–55 y.o. borderline HTN (DBP = 85–94) employed	Imputed: ψ demands (2 items) Control (12 items) Quotient term with 3 levels: high, medium, low		Low physical demand: Job strain Medium High Work +7.4 → +11.9 Leisure +5.9 → +9.9 Sleep +7.4 → +10.2	High physical demand: DBP work, leisure & sleep = NS High & low physical demand SBP work, leisure & sleep = NS

* Results not gender-stratified

(Table continued on next page.)

TABLE 4. Studies of Job Strain and Ambulatory Blood Pressure among Men *(Continued)*

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Significant Positive Effects: SBP (Adjusted Confounders)*	*Significant Positive Effects: DBP (Adjusted Confounders)*	*Null or Sig. Negative Assoc. (Adjusted Confounders)*
van Egeren, et al. (1992)	N = 17, U.S., 21–52 y.o. university employees, sedentary work, (88% white)	Self report: JCQ Cutpts of Schnall, 1990 (24% job strain-men N = 4)	Job strain Work +9 Home +5 *(Age, baseline BP, BMI, TAB, caffeine)*	Job strain Work +4 *(As SBP)*	Home DBP, sleep SBP & DBP = NS *(As SBP)*

Cohort Ambulatory BP Studies

First Author (Year)	*Study Participants*	*F/u (y)*	*Form(s) of Job Strain Variable*	*Significant Positive Effects: SBP (Adjusted Confounders)*	*Significant Positive Effects: DBP (Adjusted Confounders)*	*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Schnall, et al. (1998)	N = 195, U.S., 30–60 y.o. from 8 worksites, 84% white	3	Self report: JCQ Quadrant term (21% job strain)	Job strain at T1 & T2 vs. at neither Work +11.1 Home +11.1 Sleep +10.8 Job strain at T1, not at T2 Work −5.3 Home −4.7 *(Age, BMI, race, smoking, ETOH)*	Job strain at T1 & T2 vs. at neither Work +9.1 Home +7.3 Job strain at T1, not at T2 Work −3.2 Home −3.3 *(As SBP)*	Job Strain at T1 & Tw vs. at neither DBP sleep = NS Job strain at T1, not at T2 SBP & DBP sleep = NS *(As SBP)*
Theorell, et al. (1988)	N = 40, Swedish, 26–60 y.o., 6 different occupations	1	Self report: PSJSQ Quotient term—4 levels	Highest repeated job strain Work +4		Highest repeated job strain: Work DBP = NS Leisure SBP & DBP = NS

Case-Control Ambulatory BP Study

First Author (Year)	*Study Participants*	*Form(s) of Job Strain Variable*	*Significant Positive Effects (Adjusted Confounders)*	*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Schnall, et al. (1990)	N = 215, U.S., 30–60 y.o. from 8 worksites, 84% white	Self report: JCQ Quadrant term (21% job strain)	Job strain — OR Case defined at work ambulatory BP > 85 — 3.1 Case defined at work ambulatory BP > 90 — 3.6 Case defined at work ambulatory BP > 95 — 24.4 *(Age, BMI, type A behavior, 24 h urine Na^+ excretion, physical activity on the job, education, smoking, ETOH, work site)*	

BMI = body mass index, ETOH = alcohol, JCQ = job content questionnaire, NS = nonsignificant, OR = odds ratio, PA = physical activity, PSJSQ = psychosocial job strain questionnaire (Swedish), TAB = Type A behavior.

which recordings were continued outside work, ambulatory SBP was found to be significantly elevated during leisure, nonwork time among those exposed to job strain. One additional study, in which only main effects were assessed, shows that low skill discretion is a significant, independent predictor of ambulatory SBP during work, as well as during leisure time.[91] High psychological demands also were found to be associated with a significant elevation in ambulatory SBP during work.[228a] Ambulatory diastolic blood pressure (DBP) was significantly higher during work among those exposed to job strain, with a "carry-over effect" to leisure time in two studies.[159,227,228a,259,276]

Significant dose-response relationships were reported in three studies: when job strain was defined at a more extreme level (e.g., the top tertile of demands or the bottom tertile of latitude, or their combination—the 9th cell term; see Chapter 6), the blood pressure effect also was greater. Thus, analyzing the Schnall, et al. 1992 study and the Landsbergis, et al. study together, when job strain was defined by the usual quadrant term work ambulatory SBP showed a +6.7 mmHg effect, but when the 9th cell was used the effect rose to +11.5.[152,228a] In the study of borderline hypertensives by Theorell and colleagues, exposure to "medium" levels of job strain (and low levels of physical demand) was associated with a +7.4 mmHg effect on ambulatory DBP during work, compared to +11.9 among those exposed to "high" job strain.[259] Self-report bias was obviated in this study by use of the imputation method.

In contrast, both Blumenthal, et al. and Cesana, et al. obtained null or negative results when job strain was assessed by self-report among borderline, unmedicated hypertensives.[23,41] The latter group of authors have suggested that this may reflect a denial phenomenon. This formulation is concordant with Theorell's observations that an underreporting of a stressor may be associated with overreaction physiologically, among those with a positive family history of hypertension.[257]

In the Knox, et al. study and the Theorell, et al. 1985 study, use of the imputation method based upon single items to define the major job strain dimensions may have contributed to nondifferential misclassification.[133,262] Two single-occupation studies by Steptoe and colleagues also reveal a number of null cross-sectional ambulatory BP findings. In a group of firefighters, 51% were deemed to have been exposed to job strain, based upon a small number of items for each dimension.[249] Using similar methodology, 49% of teachers (not gender stratified) were said to have been exposed to job strain.[248] Nondifferential misclassification due to limited range of variation of actual job characteristics may explain these results. Nevertheless, when job strain exposure status was combined with systolic reactivity, a significant positive effect upon afternoon work SBP was found (+12.4) among the firefighters. Among the teachers, the difference in BP between evening and day work was significantly less among those with high (–0.64/–2.45) versus low (–3.72/–4.5) job strain (not gender stratified).

The case-control study of Schnall, et al. reveals a significant positive relation between exposure to job strain and hypertensive status, as defined by work ambulatory BP.[228] Furthermore, as the definition of hypertension was made progressively more rigorous (work ambulatory BP > 85, 90, and 95 mmHg), the odds ratio for exposure to quartile-term job strain increased correspondingly (3.1, 3.6, and 24.4, respectively).

Both cohort ambulatory BP studies report significant positive findings. In the Schnall, et al. 1998 study, exposure to job strain at baseline and 3 years later showed a +11.1 mmHg effect on workplace and home ambulatory SBP compared to those

unexposed at both times.[227] The DBP effect also was marked. Furthermore, those men who reported being exposed to job strain at baseline but not 3 years later showed a significant drop in work and home ambulatory BP at 3-year followup, after controlling for major confounders.

Casual Blood Pressure Studies. Studies of job strain in relation to casual BP (usually measured in the clinic or other unspecific setting outside the workplace) are generally less consistent than those using ambulatory recordings at the workplace. Significant positive effects of exposure to job strain among men were found with respect to casual SBP in the cross-sectional studies of Cesana, et al., among normotensives but not borderline hypertensives, and of Melamed, et al., in which exposure to hectic, short-cycle, repetitive work was compared to jobs with substantial variety or longer cycle.[41,173] Kawakami and colleagues reported a significantly elevated SBP and DBP among day workers exposed to job strain, but not among those working rotating shifts.[130] In only one of the five large databases assessed by Pieper, et al. was exposure to job strain using the imputation method significantly associated with casual SBP and DBP.[209] However, a summary estimate of all five working population samples revealed a significant relation between a low decision-latitude and SBP. In a similar vein, Curtis, et al. found a significant inverse relation between hypertensive status based on casual BP readings and self-reported decision latitude at work.[52]

In contrast, in other studies neither exposure to job strain nor its major dimensions (when analyzed) were associated with hypertensive status or BP levels, based on casual BP readings.[4,9,40,64,110,252] (In the Carrère, et al. study, BP was measured immediately pre- and post-work.) In the investigations of Greenlund, et al. and Netterstrøm, et al., nonsignificant relations (gender-adjusted but not stratified) between job strain or its major dimensions and casual BP measures were found, with a few unexpected inverse relations in the latter study.[82,186] A cohort study by Chapman, et al. revealed that exposure to deadlines at work was associated with a significant increase in SBP, while other single or interaction terms reflecting job strain and/or its major dimensions showed no significant relations to SBP nor DBP among men.[43]

The papers of Albright, et al., Carrère, et al., and Emdad, et al. are on single occupations, and therefore are of limited range of variance.[4,40,64] The major issue, however, for most of these studies, is that casual BPs are highly variable and, in the clinic setting, may be influenced by psychosocial factors related to the clinic visit itself, the so-called "white coat effect."[207] Worksite point measurements of BP appear to be more reliable than casual clinic BP (see Chapter 7). Schnall and colleagues found that workers exposed to job strain showed an increased likelihood of having hypertension, classified on the basis of worksite point measurements of BP.[228] Furthermore, as the definition of hypertension was made more stringent, the odds ratio increased, providing additional evidence of the reliability of workplace point estimates, as well as the criterion validity of the relation between job strain and BP elevation.

Thus, with respect to casual BP, we find limited evidence that job strain or its dimension(s) has a major impact. This is in contradistinction to studies that measure ambulatory BP and examine averaged BPs during work, as well as other periods, as the outcome. These studies show strong, consistent effects of job strain or its major dimension(s) on BP. Furthermore, there is some evidence, albeit not totally consistent, of a dose-response relationship with respect to ambulatory BP and exposure to increasingly severe job strain. In addition, there is cohort data demonstrating not only the expected temporal relationship between exposure and outcome,[227] but also the effect of cumulative exposure. Finally, the data, albeit observational rather than a

controlled intervention, indicate that "*a change in exposure* is associated with a ***change in morbidity***."[227] Hernberg has categorized the latter as "the most conclusive evidence of causality."[100]

OTHER CARDIAC RISK FACTORS

Some studies indicate that exposure to job strain and/or its major dimensions is associated with other standard cardiac risk factors among men. There are theoretical background discussions on how work organizations can influence health-related behaviors that impact upon the CV system.[113,151]

With regard to **cigarette smoking**, it has been proposed that workplace stressors have less impact on smoking prevalence than on smoking intensity, since people often begin smoking before entering the labor market.[283] Accordingly, the focus here is on results concerning smoking intensity among current smokers. Green and Johnson found, after controlling for sociodemographic factors, that male chemical plant employees in higher-strain work smoked significantly more cigarettes, and more of them had increased the number of cigarettes smoked, compared to those with lower-strain jobs.[81] Hellerstedt and Jeffery also reported a significantly greater number of cigarettes smoked per day among men in high-strain jobs compared to passive jobs, after sociodemographic adjustment.[98] Kawakami, et al. found that high-strain jobs *and* passive jobs with low social support were associated with increased smoking intensity.[130] Other studies also reveal a significant positive association between job strain and/or its major dimensions and smoking intensity among men.[176,209]

However, in a study of young adults, after adjusting for age, education, and type A behavior, Greenlund and colleagues found no significant relation between self-reported job demands, decision latitude, job strain, and smoking intensity.[82] Among male professional drivers, no significant relation was found between self-reported job strain, psychological demands, decision latitude, and smoking intensity.[63] Two imputational studies, in which sociodemographic adjustment was not made, also reveal no association between exposure to job strain and/or its major dimensions, and how much workers smoke.[9,218] In the one prospective study in which changes in smoking prevalence were examined, men whose job decision latitude increased over 3 years had a substantial reduction in cigarette smoking. The greatest increase in decision latitude was found among those 13 men who quit smoking.[151]

Sedentary behavior during nonwork time was found to be significantly associated with less social interaction at work, as well as with fewer opportunities to learn new things on the job (an integral part of the decision-latitude), in a population-based sample of Swedish men, after adjusting for age and education.[113] Similarly, another study found a significant inverse relation between low decision-latitude and number of exercise sessions per week, after sociodemographic adjustment.[98] However, no significant association was found between sedentary leisure time and job strain or its major dimensions in the study of Landsbergis, et al.[151]

Obesity, as assessed by detailed anthropometric measurements, has been found among Hispanic men in the U.S. (HHANES study) to be significantly associated with exposure to job strain, decision authority, and psychological demands (imputation method), after adjusting for age, education, and smoking status.[78] Netterstrøm and colleagues reported that both self-reported and imputed exposure to job strain were associated with a significantly elevated body mass index (BMI) in a sample of men and women; these results were adjusted for, but not stratified by, gender.[186] In contrast, a number of other studies relying upon BMI show no relation between job

strain or its major dimensions and BMI among men.[98,110,151,218] In a study of male professional drivers, an inverse relation was found between self-reported job strain and self-reported BMI.[63] This finding was attributed to denial, which has been shown to deleteriously impact upon cardiac risk among professional drivers.[187,292]

Hellerstedt and Jeffery found a significant relation between **high-fat diet** and exposure to high psychological demands, as well as job strain.[98]

Psychosocial stressors may promote atherogenic processes (see Chapter 5). Here, we briefly summarize the epidemiologic data concerning these metabolic parameters and job strain and/or its major dimensions. Ishizaki, et al. found that low psychological demands significantly predicted tissue plasminogen activator levels, independently of traditional cardiac risk factors.[110] Elevated fibrinogen was reported by Brunner and colleagues in the Whitehall II study to be associated with low workplace control, as assessed both by self-report and external observer.[36] In the former case, this effect remained after adjustment for socioeconomic status. However, Ishizaki, et al. found neither job strain nor its major dimensions significantly associated with plasma fibrinogen levels. Moller and Kristensen also failed to find that job strain was a significant, independent predictor of plasma fibrinogen levels, using a multivariate model that included social class.[178]

Of the studies that have examined the relations between serum cholesterol and/or its constituent fractions, and job strain or its major dimensions, no significant results among men have been reported.[9,67,82,110,130,173,180,186,218] Netterstrøm, et al. reported that HbA1C was significantly associated with imputed exposure to job strain in a sample of men and women; these results were adjusted for, but not stratified by, gender.[186] Other studies assessing glucose intolerance showed no significant relation to job strain or its major dimensions among men.[67,82,110,173]

Thus, there is preliminary evidence that job strain or its major dimension(s) may impact on cardiac risk factors besides BP. Some noteworthy results are seen regarding smoking intensity. There are some suggestive data regarding links to the coagulation mechanisms and other metabolic indices contributing to the atherogenic process; however, there are also substantial null findings. Much additional research is needed before definitive conclusions can be reached in this area.

The Effort-Reward Model

Ischemic Heart Disease and Other Hard CVD Endpoints

Measures of effort-reward imbalance (ERI) at work have been found to predict new manifestations of coronary heart disease in Germany, Finland, and England (Table 5). In a prospective study of 416 German factory workers aged 25–55, a number of measures of high effort and low reward independently and strongly predicted CHD incidence over 6.5 years after adjusting for other behavioral and somatic risk factors.[239] These measures included status inconsistency (OR 4.4), job insecurity (OR 3.4), work pressure (OR 3.5), and overcommitment (OR 4.5). A combined "low reward/high effort" variable was also a significant predictor (OR 3.4) in a separate analysis. If advanced, subclinical CHD (OR 6.2) or stroke (OR 8.2) is added to the case definition, the association with ERI becomes even more substantial.[233]

Among men in the British Whitehall study, exposure to a combination of high effort and low reward more than doubled the risk of newly reported CHD over 5.3 years.[30] Finally, in a prospective study of Finnish men, those facing high work demands, low work resources, and low income had a more than doubled risk of myocardial infarction or dying from heart disease after 8.1 years, compared to men with low demands,

TABLE 5. Studies of the Effort-Reward Imbalance Model and Cardiovascular Outcomes for Men

Cohort Studies

First Author (Year)	*Study Participants*	*Form(s) of Exposure Variable*	*F/u (y)*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Siegrist, et al. (1990)	416 male German blue-collar workers from 3 factories	Low security, career opportunities: job insecurity or status inconsistency High effort: work pressure or overcommitment	6.5	Acute MI or SCD (n = 263 in analysis)		OR	Job instability, piecework, shiftwork, noise, increase in workload = NS; low promotion prospects
					Status inconsistency	4.4	
					Overcommitment	4.5	
					Low security, career opportunities *or* high effort	4.5	Not significant controlling for other measures of low security, career opportunities and high effort
					Low security, career opportunities *and* high effort	30.6	Job insecurity
					(Age, BMI, SBP, lipids)		Work pressure
Siegrist & Peter (1994); Siegrist (1996)				Acute MI, SCD, or advanced (sub-clinical) CAD (n = 329 in analysis)	Work pressure	2.5	
					Low security, career opportunities, *or* high effort	2.4	Overcommitment
					Low security, career opporunities, *and* high effort	6.2	
Siegrist, et al (1992); Siegrist (1996)				Acute MI, SCD, or stroke	Overcommitment	3.6	
					Status inconsistency	2.9	
					Low security, career opportunities, *and* high effort	8.2	
					(Age, BMI, BP, lipids, smoking, exercise)		
Lynch (1997a)	N = 940, Eastern Finnish men, 42-60 y.o., population-based	• Stress from work demands scale (11 items split at high 20%) • Economic rewards scale (income, split at low 20%)	4.2	Progression of carotid athero-sclerosis (plaque height, max. & mean IMT)	High demands, low income	p	Groups with other combinations of demands and income = NS
					For change in max. IMT	0.03	*(Age, baseline IMT)*
					For change in plaque height	0.008	
					(Age, baseline IMT)		
					For change in plaque height	0.04	
					(Age, HDL, LDL, triglycerides, smoking, alcohol, BMI, SBP, treated hypertension or hyperlipidemia)		

(Table continued on next page.)

TABLE 5. Studies of the Effort-Reward Imbalance Model and Cardiovascular Outcomes for Men *(Continued)*

First Author (Year)	*Study Participants*	*Form(s) of Exposure Variable*	*F/u (y)*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Lynch, et al. (1997b)	N = 2297, Eastern Finnish men, 42–60 y.o., population based	• Stress from work demands scale (11 items) • Resources scale (5 items) (skill discretion/emotional rewards of work; interesting, enjoyable, meaningful work) • Economic rewards scale (income, split at low 40%) Referent = low, high, high	8.1	Acute MI	High demands, low resources, low rewards *(Age, alcohol, smoking, physical activity)* *(Age, depression, marital status, hopelessness)* *(Age, fibrinogen, SBP, BMI, CV fitness, lipids, other bioRF)*	RH 2.3 2.2 1.9	Groups with other combinations of demands, resources, rewards = NS *(Age)*
				CVD mortality	High demands, low resources, low rewards *(Age, alcohol, smoking, physical activity)* *(Age, fibrinogen, SBP, BMI, CV fitness, lipids, other bioRF)*	2.6 2.3	
Bosma, et al (1998)	10,308 British civil servants (33% women), 35–55 y.o.	High effort: competiveness, overcommit., hostility Low reward: poor promotion prospects, blocked career	5.3	Newly reported CHD (results for men)	High effort and low reward *(Age, BMI, smoking, BP, lipids, employment grade, negative affectivity, length of followup, job control)*	OR 2.2	High effort *or* low reward

Cross-Sectional Study

First Author (Year)	*Study Participants*	*Form(s) of Exposure Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Peter, et al (1999b)	2098 Swedish men and women, 45–64 y.o., population based case-control SHEEP study	Effort-reward imbalance: ratio > 1 Job strain: latitude bottom 25% or demands top 25%	Acute nonfatal MI (results for men)	Effort-reward imbalance (no job strain) Effort-reward imbalance *and* job strain *(Age, BMI, smoking, HPT, lipids, exercise, diabetes, family history, SES)*	OR 1.4 2.3	

bioRF = biological risk factors, CAD = coronary artery disease, CVD = cardiovascular disease, HPT = hypertension, IMT = intima-media thickness, MI = myocardial infarction, SCD = sudden cardiac death.

high resources, and high income.[165] In addition, in this sample a combination of high work demands and low income was significantly associated with progression of carotid atherosclerosis.[164] (In the German and Finnish studies, some measures of high effort or low reward were not associated with heart disease, as shown in Table 5.)

BLOOD PRESSURE

As seen in Table 6, in the cross-sectional study of 179 male German middle managers aged 40–55, forced job change (low reward) (OR 3.3) and a variable combining frequent interruptions (effort) and forced job change (OR 5.8) were strongly associated with hypertension.[205] Similarly, in a cross-sectional study of Stockholm area residents, an effort-reward ratio greater than one was associated with hypertension (OR 1.6) among men.[202] The combination of ERI and shiftwork among Stockholm men led to an even stronger association (OR 2.2) with hypertension.[203]

In the prospective study of 416 German blue-collar workers from three factories, low promotion prospects at work (OR 2.7), competitiveness at work (OR 2.8), and feelings of sustained anger (OR 5.4) predicted coronary high risk status.[238] (High risk was defined as the 13.6% of the sample with both hypertension and high lipid levels.) In addition, a variable combining overtime work (effort) and fear of job loss, job instability, and layoffs (low reward) was similarly associated (OR 3.3) with a comanifestation of hypertension and atherogenic lipids.[233] (In all of these studies of hypertension, some of the measures of high effort or low reward were not associated with hypertension; see Table 6.)

OTHER CARDIAC RISK FACTORS

Cardiac risk factors other than hypertension may represent additional pathways by which ERI may contribute to CVD. Among German blue-collar workers, LDL/HDL ratio was associated with high work demand, increased workload, and job insecurity, combined with occupational instability.[235] In German managers, LDL cholesterol was predicted by a combination of workload and lack of support.[237] In Swedish men, cholesterol/HDL ratio, but not plasma fibrinogen, was associated with ERI.[202,203] Among the German managers, fibrinogen was associated with a combination of overcommitment and lack of social ("reciprocal") support, but not with combinations of other measures of effort or reward.[237]

COMMENTS ON THE NULL FINDINGS AND GENERAL INTERPRETATION

Despite the positive findings, some questions remain about which specific work factors are responsible for increasing CHD risk, and whether these variables are additive or interactive.

Specific Predictors of Risk. In the earlier studies, the set of variables used to measure effort and reward was not always identical, as some studies used "proxy" measures.[30,164,165] In addition, Siegrist, et al. applied a less restrictive measurement approach where subjects were considered "exposed" to ERI when at least one of the effort and one of the reward variables were positive.[238,239] Thus, we cannot be sure which work characteristic contributed to this combined risk factor. More recently, a standardized summary measure of ERI has been constructed based on a predefined algorithm.[202–204] To illustrate this issue, in the three studies of hypertension (Table 6), only the German middle-manager study found associations between outcome and measures of extrinsic effort.[205] Extrinsic effort was not associated with hypertension in the Swedish WOLF study.[202] In the German blue-collar study, work pressure was not associated with outcome, and forced piecework was not in the analysis (due to

TABLE 6. Studies of the Effort-Reward Imbalance Model and Hypertension for Men

Cohort Studies

First Author (Year)	*Study Participants*	*Form(s) of Exposure Variable*	*F/u (y)*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Siegrist, et al. (1991); Siegrist (1996)	416 male German blue-collar workers from 3 factories	Low security, career opportunities: job instability, low promotion prospects Overcommitment: competitiveness, sustained anger High effort-low reward: overtime *and* job instability *or* fear of job loss	6.5	Comanifestation of hypertension and high LDL-cholesterol (n = 314 in analysis)	<u>QR</u> Low promotion prospects 2.7 Competitiveness 2.8 Sustained anger 5.4 High effort-low reward 3.3 *(Age, BMI, smoking, exercise)*		Work pressure, job instability; forced piecework and status inconsistency were not in the analysis, due to attempts to find the most parsimonious model

Cross-Sectional Studies

First Author (Year)	*Study Participants*	*Form(s) of Exposure Variable*	*Illness Outcome*	*Significant Positive Associations (Adjusted Confounders)*		*Null or Sig. Negative Assoc. (Adjusted Confounders)*
Peter & Siegrist (1997); Siegrist (1996)	179 healthy German male middle managers, 40–55 y.o.	High extrinsic effort: time pressure, frequent interruptions High intrinsic effort: overcommitment (upper tertile), sustained anger Low reward: lack of support, status incongruence, status discrepancy forced job change	Hypertension (≥ 160/95 mmHg) (n = 170 in analysis)	<u>Bivariate analysis:</u> Time pressure Frequent interruptions Forced job change Freq. interruptions + forced job change <u>All exposure variables in model:</u> Forced job change <u>Effort-reward imbalance measures:</u> Freq. interruptions *or* forced job change Freq. interruptions + forced job change *(Age, BMI, smoking, exercise)*	<u>QR</u> 3.3 2.3 5.8	Overcommitment Sustained anger Lack of support Status incongruence Status discrepancy Time pressure Frequent interruptions
Peter, et al (1998)	N = 2228, Swedish men, 30–55 y.o., population-based WOLF study	Effort-reward imbalance: (ratio > 1): overcommitment (upper tertile), extrinsic effort (above median), low reward (above median)	Hypertension (≥ 160.95 mmHG) (results for men)	<u>Bivariate analysis:</u> Effort-reward imbalance <u>Low reward</u> Effort-reward imbalance *(Age, smoking, BMI, exercise)* Effort-reward imbalance *(Age, smoking, BMI, exercise, lipids, SES)*	<u>QR</u> 1.7 1.6	Overcommitment Extrinsic effort
Peter, et al (1999a)		Rotating shift workers (vs day shift)		Effort-reward imbalance + rotating shift *(Age, smoking, BMI, exercise)*	2.2	

BMI = body mass index, SES = socioeconomic status.

colinearity).[238] Only in one later analysis of the sample was overtime (plus low reward measures) associated with high CHD risk.[233] Similarly, "forced job change" in the middle manager study and "low promotion prospects" in the blue-collar study were the only low reward measures associated with hypertension. ("Status inconsistency" was not in the analysis of the blue-collar sample due to colinearity with other reward measures.)

In the CHD studies (Table 5), no extrinsic measure was included in the Whitehall study analysis,[30] and a very broad measure of work demands was used in the Finnish studies.[164,165] Low status control (low job security) was essentially the measure of low reward in the German blue-collar sample and the Whitehall study, while economic reward and social support were added as measures of reward in the Finnish and the Swedish SHEEP studies.

Interaction Versus Additive Burden. As with the Job Strain Model, the question arises as to whether measures of high effort and low reward combine with each other additively to increase CHD risk, or whether they interact with each other ("synergism," see Chapter 3). In some analyses, as seen in Tables 5 and 6, synergism appears to exist. In the blue-collar study and the middle manager study, for example, the relative risk of CHD due to measures of high effort combined with low reward is substantially greater than the sum of the risks due to these two components separately.[205,233] However, no statistical tests of interaction were conducted. A number of more recent analyses used a combined high effort-low reward ratio variable, which prevents observation of possible interaction.

In summary, several studies, both cross-sectional and prospective, have shown significant positive associations between measures of high effort/low reward and elevated lipid levels, hypertension, and CVD. The magnitude of the relationship is similar to that typically found for job strain with respect to these outcomes. Furthermore, preliminary evidence indicates that the effects of job control and ERI are statistically independent of each other in prediction of CHD[30] and that the combined effects of exposure to job strain and ERI upon CVD are much stronger than the separate effects of each.[204]

Threat-Avoidant Vigilant Work

A particularly heavy psychological burden occurs when one must continuously maintain a high level of vigilance to avoid disastrous consequences, which could occur with a momentary lapse of attention or a wrong decision. Among several of the occupations shown to be at high risk for CVD (e.g., bus, taxi, and truck drivers; air traffic controllers; sea pilots), threat-avoidant vigilant activity is a prominent aspect of work. Experimental animal studies have shown an association between performance of threat (shock) avoidance tasks and cardiac electrical instability.[46,162]

A few epidemiologic studies have specifically examined aspects of threat-avoidant vigilant activity with regard to CVD outcomes. In a cohort study by Menotti and Seccareccia of 99,029 Italian men employed by the railroad system, occupational psychologists rated jobs with respect to level of "responsibility at work."[175] Levels were based on the "economic and financial implications of decisions taken at work, as well as the relevance of possible damage and hazards both economic and for human life as a consequence of possible mistakes made at work." The age-adjusted mortality rates due to MI were significantly greater ($p < 0.001$) for each of three ascending levels of responsibility at work compared to the lower levels. Job dimension data from expert ratings were imputed to a CV disability data base ($N = 9855$).[181] For the dimension of having to be "alert to changing conditions," age-adjusted ORs of

1.85, 2.17 and 2.8 were found for the second, third, and highest quartiles, respectively. The "hazardous job situation" dimension showed age-adjusted ORs 2.07, 3.32, and 4.09, for the second, third, and highest quartiles, respectively. (Confidence intervals were not provided; the author identified job dimension scores having an OR of at least 2 as meriting additional research attention.) In the imputational study by Alfredsson, et al., an SMR of 132 (116–149) was calculated for hospitalization for MI, among Swedish men whose jobs entailed risk of explosion.[7] Occupational titles were used to impute job characteristics based upon observational analysis and interviews in a study of 6213 Finnish municipal employees.[251] These authors identified requisites for "alertness of the senses" and dangerous work as quantitatively important stressors among male transport workers, with high prevalence of self-reported hypertension and CHD.

These epidemiologic studies provide suggestive evidence for an association between aspects of threat-avoidant work and CVD outcomes. Further investigation is needed, with more precise, well-controlled risk estimates, and accounting of biomedical and psychosocial risk factors.

SOCIAL CLASS, OCCUPATIONAL STATUS, AND CVD *by Michael Marmot, FFPHM—Supported by an MRC research professorship and by the John D. and Catherine T. MacArthur Research Foundation Research Network on Socioeconomic Status and Health*

A dominant feature of the occurrence of cardiovascular disease (CVD) in most industrialized societies is the higher rate in people of lower socioeconomic position. The Whitehall studies of British civil servants showed that the link between socioeconomic position and CVD was not confined to higher rates among the poor.[169,170] The poor do have high rates, but there is a social gradient: the lower the social status, the higher the CV risk. A review by Kaplan and Keil covers a wealth of studies showing a similar social gradient in the U.S.[118]

What implications does the social gradient have for questions of etiology and in particular for the role of work? In the U.K., we traditionally used Registrar General's social classes, which are based on occupation. It has never been clear whether the differences in CVD observed using these classes are due to occupation or to other features correlated with occupational status.

Elsewhere in this volume we show how ideas on the effects and meaning of social stratification have been shaped by Marx, Durkheim, and Weber. It is useful to think of three "meanings" of socioeconomic position, in terms of the ways they may affect health. First, low social position may be related to **material deprivation**, and absolute material deprivation (poverty) may be related to risk of illness. Second, socioeconomic position may be related to **standing in society** which may, in turn, relate to shared values, culture, and lifestyle. Third, socioeconomic position is a measure of position in the social hierarchy, which is related to **power relationships**. People higher in the hierarchy have more control over their own, and other people's, lives. These power relations operate in the workplace, but not exclusively so.

Figure 1 shows standardized mortality ratios from ischemic heart disease (IHD) by Registrar General's social classes in England and Wales.[56] Focusing on the 1991–93 period, we see that IHD is markedly higher among men in social class V, unskilled manual workers. The gradient is shown clearly. Men in social class I have a mortality ratio about 35% lower than the England and Wales average, and men in social class IV