MEASUREMENT OF PSYCHOSOCIAL WORKPLACE EXPOSURE VARIABLES

SELF-REPORT QUESTIONNAIRES *by Paul Landsbergis, PhD, and Töres Theorell, MD, PhD*

Despite differences in the ways workplace CVD risk factors—psychosocial, chemical, physical, and schedule-related—are measured, basic similarities exist. All require assessment of the duration, intensity, and frequency of exposure. To assess duration of exposure (or cumulative exposure), "detailed work history records [are] virtually essential. . . . where job mobility occurs frequently."[16] A job-exposure matrix is necessary when individual data are not available (or for more objective measures of psychosocial factors). Data in such a matrix can be provided at broader or narrower levels of aggregation, i.e., broad occupational categories or specific job titles in specific companies or work areas. For more detail on physical and chemical exposure assessment, we refer the reader to basic texts in occupational epidemiology[16] and industrial hygiene.[18]

Research and debate have been spurred by efforts to develop more objective measures and other measurement issues. First, should one use occupation-specific measures, or measures that can be generalized across occupations? Second, which aspects of work should be measured: job characteristics (e.g., demands, control), role characteristics, organizational climate, hours, or broader systems of work organization (e.g., lean production)? Third, are the characteristics a property of the individual, job, job title, occupation, or organization? Fourth, which questionnaires based on which theories best measure psychosocial exposures associated with an increased risk of CVD?

Here, we do not focus on measuring the perception of stress. Due to adaptation, people working in a stressful job may not report feelings of stress. For example, in the Cornell blood pressure (BP) study, job strain (high job demands plus low job decision latitude) was not associated with perceived anxiety or distress.[63] Nor do we examine interactions between personality and the work environment. Rather, we focus on **job stressors**—the large number of environmental conditions at work "thought to impact on the health and well-being of the worker."[43]

Occupation-Specific Versus General Measures

One approach to developing job stressor questionnaires has been to ask questions *specific* to a particular occupation or a workplace, for example, nurses,[27] teachers,[85] or bus drivers.[9,59,109] Such measures provide rich, detailed information, especially for intervention efforts[43] designed to identify and change specific features

of the work environment associated will ill health. For example, in the San Francisco bus driver study, back and neck pain were associated with a number of job conditions such as equipment problems, too many passengers, problems with supervisors, not maintaining the run schedule, long or odd hours, having been "written-up" for rule violations, serious traffic or road problems, and poor access to restrooms on the line.[59] Interestingly, a sum score of such job conditions was found to be inversely associated with hypertension (when measured by job stressor questionnaire in 1983–85), or not associated with hypertension (when measured in 1993–95). Such findings highlight the need to also employ more objective measures of job stressors.

Since job-specific questionnaires cannot be used to compare job stressors across different occupations, an alternative approach has been to measure generic or *global* job characteristics, such as demands, control, and social support, using language general enough to apply to a variety of occupations.[9,56,69,91] This approach is less useful for intervention studies because questions are more "remote from actual work experiences."[43] It has been essential, however, to the development of theories of job stress, such as the demand-control model and the effort-reward model, which have enabled researchers to document associations between job characteristics and CV outcomes across occupations (see Chapters 2 and 3).

A recent innovative approach uses occupation-specific questions (useful for workplace interventions), which are based on general questions.[10] The Occupational Stress Index (OSI) can be tailored to specific occupations, thus allowing comparison among occupations of the stress burden faced by workers.

Measuring Job Characteristics: Questionnaires and Theoretical Models

The global job stressor questionnaires focus, for the most part, on characteristics of individuals' jobs (Table 1), rather than on systems of work organization. Only occasional questions ask about broader issues such as employee influence over departmental or employer policies or procedures, representative influence through labor organizations, or promotion prospects. Similarly, few questionnaires measure systems of management, such as electronic monitoring or piece-rate pay systems, or new systems of work organization, such as lean production, total quality management, cellular or modular manufacturing, or patient-focused care.[62] These new work systems may have dramatic impacts on task-level job characteristics; research suggests that some systems increase job stressors.[62]

Modern job stress assessment "was given tremendous impetus by research conducted at the University of Michigan in the early 1960s."[43] Questionnaires were developed to measure factors such as role ambiguity, workload, role conflict, responsibility for persons or things, participation, and social relations. The Michigan researchers hypothesized that stress is greatest when there is a misfit between a person's abilities and work demands, or a person's motives and the work environment's "supplies" to satisfy these motives.[15] This Person-Environment (P-E) Fit model focuses on individuals' subjective perceptions of the work environment, and incorporates a variety of perceived and objective stressors, feedback loops, and the potential moderating effects of personality factors, nonwork factors, and demographic measures. However, this model has "demonstrated limited ability to predict what objective work conditions are likely to result in stress."[7]

NIOSH has developed an extensive questionnaire to measure job stressors, based, in part, on the University of Michigan questionnaire.[72] Over 100 questions, included in 20 scales with high internal consistency, ask about stressors in the work

TABLE 1. Content of Questionnaires Used to Measure Job Stressors in Studies of CVD

	Core JCQ	Full JCQ	DCQ	WOM	Whitehall	ERI	OSI
	(No. of Questions)						
Psychological Job Demands							
Time pressure, workload	4	5	5	2	4	2	3
Conflicting demands	1	1					1
Intense concentration		1					1
Interruptions		2				1	1
Increasing demands						1	
Responsibility						1	2
High demand							19
Avoidance/disaster potential							5
Conflict/uncertainty							8
Job Decision Latitude/Control							
Skill discretion	6	6	4	3	6		5
Decision-making authority	3	3	2	8	9		3
Underload							8
Strictness							6
Skill underutilization	2	2					4
Status inconsistency						1	
Work group decision authority		3					
Formal authority		2					
Union/representative influence		3					
Social Support							
Supervisor support	4	5			4		
Coworker support	4	6		4	2		
General support						1	1
Respect						3	
Unfair treatment						1	
Job Insecurity							
General job insecurity	3	4				2	
Skill obsolescence		1					
Promotion prospects		1				2	
Physical Demands							
General physical loading	1	1				1	
Isometric load		2					
Aerobic load		2					
Noxious Exposures/Aversiveness				7			7
Income						1	
TOTAL	28	50	11	24	25	17	74

JCQ = Job Content Questionnaire; DCQ = Swedish Demand-Control Questionnaire; WOM = Swedish Work Organization Matrix; ERI = Effort-Reward Imbalance; OSI = Occupational Stress Index

Notes: This table does not include the 29 questions from the ERI intrinsic effort scale, because intrinsic effort is considered to be a personality trait. The number of OSI questions does not total to 58 since the same items may be used to form more than one scale.

Adapted from Karasek R, Brisson C, Kawakami N, et al: The Job Content Questionnaire: An instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 3:322–355, 1998; with permission.

environment. While the NIOSH questionnaire (and the earlier P-E Fit questionnaire) have been used in numerous studies examining self-reported psychological strain outcomes (e.g., anxiety, depression) and job dissatisfaction, they rarely have been used to study CV outcomes.

Since the 1960s, ". . . a plethora of questionnaires, scales, interview schedules and other stress measurement devices have emerged and evolved. . . . choosing a measurement tool poses a bewildering challenge."[43] Hurrell, et al. point out that many of these questionnaires have good reliability and construct validity, and therefore are potentially useful for studying working conditions related to CVD.[43] Here, we focus on the questionnaires that have been widely used in studies of CVD to describe working conditions (see Table 1).

Job Content Questionnaire

The core questions of the Job Content Questionnaire (JCQ)[53,56] are taken from the U.S. Quality of Employment Surveys (QES), administered to nationally representative samples of employed individuals in 1969, 1972, and 1977. The "core JCQ" is based on 27 psychosocial questions included in the three QES. The "full JCQ" (version 1.1) was developed in 1985 by adding eight additional QES items and 14 new questions. A 1995 update (version 1.5) included pilot versions of a set of questions addressing the global economy. JCQ scale scores for any sample can be compared to national U.S. scale averages by job title, sex, and industry code.

The JCQ has been widely used in North America, Europe, and Japan, and reliability information contained in Table 2 is based primarily on six major studies from the U.S., Canada, the Netherlands, and Japan.[53] The means and standard deviations of scales are similar across the six studies, and internal consistency tends to be similar across populations (average Cronbach's α for women is .73 and for men is .74). The alpha coefficients are generally acceptable ($\alpha > .70$), however, the five-item psychological demands scale is only borderline (average $\alpha = .63$), and the three-item job insecurity scale has low reliability ($\alpha < .60$) for two of the three studies for which data are available. Studies using the JCQ typically have employed a response format based on intensity, i.e., ranging from "strongly agree" to "strongly disagree."

To obtain the JCQ: www.uml.edu/Dept/WE/jcq.htm

Swedish Demand-Control Questionnaire

The Swedish Demand-Control Questionnaire (DCQ), a shortened and modified version of the JCQ, was introduced in 1988[99] and has been used in a number of epidemiologic studies. It contains only six questions assessing decision latitude (two on decision authority and four on intellectual discretion). These scales have adequate internal consistency ($\alpha = .75–.80$ for demands and $\alpha = .76–.77$ for latitude).[97] There is also a social support scale; however, it is oriented toward the atmosphere in the worksite, while the JCQ social support questions are more objective and instrumental in nature. Response options are frequency-based (i.e., "how often"). The DCQ and the JCQ appear to be very similar.

A recent study explored the validity of some of the most crucial questions in the DCQ by asking subjects to describe in their own words what they mean by their responses to the standardized questionnaires. According to a content analysis, the questions dealing with psychological demands and decision latitude have similar meaning to both healthcare personnel and workers who deal with "things" in their daily work.[2]

To obtain the DCQ: e-mail Tores.Theorell@ipm.ki.se

TABLE 2. Internal Consistency Reliability of Main Questionnaire Scales Used to Measure Job Stressors in CVD Studies

Scale	Questionnaire	# of Items	Reference	Cronbach's Alpha
Psychological demands				
Psychological demands	JCQ	9	Karasek, 1998	.72 (men), .71 (women)
Psychological demands	JCQ	5	Karasek, 1998	.63 (men), .63 (women)
Psychological demands	JCQ	5	Original analyses-Cornell WSBPS	.70–.74
Psychological demands	DCQ	5	Theorell, 1996	.75 (men), .81 (women)
Psychological demands	WOM	2	Johnson, 1993	.60
Job demands	Whitehall	4	Bosma, 1997	.67
Extrinsic effort	ERI	6	Rothenbacher, 1998	.76
Extrinsic effort	ERI	6	Vrijkotte, 1999	.76
High demand	OSI	19	Belkic, 1995b; 1996	.80
Extrinsic time pressure	OSI	5	Belkic, 1995b, 1996	.54
Avoidance/serious consequences	OSI	5	Belkic, 1995b; 1996	.67
Conflict/uncertainty	OSI	8	Belkic, 1995b; 1996	.80
Job decision latitude				
Skill discretion	JCQ	6	Karasek, 1998	.73 (men), .75 (women)
Skill discretion	JCQ	6	Original analyses-Cornell WSBPS	.72–.80
Decision authority	JCQ	3	Karasek, 1998	.68 (men), .68 (women)
Decision authority	JCQ	3	Original analyses-Cornell WSBPS	.77–.81
Organizational influence	JCQ	3	Landsbergis, 1994	.62
Job decision latitude	JCQ	9	Karasek, 1998	.81 (men), .82 (women)
Job decision latitude	JCQ	9	Original analyses-Cornell WSBPS	.81–.83
Job decision latitude	DCQ	6	Theorell, 1996	.76 (men), .77 (women)
Work control	WOM	12	Johnson, 1993	.75
Job control	Whitehall	15	Bosma, 1997	.84
Underload	OSI	8	Belkic, 1995b; 1996	.62
Strictness	OSI	6	Belkic, 1995b; 1996	.41
Social support				
Supervisor support	JCQ	4	Karasek, 1998	.84 (men), .84 (women)
Supervisor support	JCQ	4	Original analyses-Cornell WSBPS	.87–.89
Co-worker support	JCQ	4	Karasek, 1998	.75 (men), .77 (women)
Co-worker support	JCQ	4	Original analyses-Cornell WSBPS	.67–.72
Social support	Whitehall	6	Bosma, 1997	.79
Job insecurity				
Job insecurity	JCQ	3	Karasek, 1998	.61 (men), .58 (women)
Job insecurity	JCQ	3	Original analyses-Cornell WSBPS	.46–.77
Extrinsic reward				
Extrinsic reward	ERI	11	Rothenbacher, 1998	.81
Extrinsic reward	ERI	11	Vrijkotte, 1999	.82
Hazardous exposures				
Hazardous exposure	WOM	7	Johnson, 1993	.71
Noxious exposure	OSI	7	Belkic, 1995b; 1996	.67
TOTAL OSI	General OSI	58	Belkic, 1995b; 1996; Emdad, 1998	.81
	Professional driver OSI*	27	Belkic, 1996	.84

* Variable items only for Cronbach alpha JCQ: Job Content Questionnaire; ERI: Effort-Reward Imbalance Questionnaire; OSI: Occupational Stress Index; DCQ: Swedish Demand-Control Questionnaire; WOM: Swedish Work Organization Matrix; WSBPS: Work Site Blood Pressure Study

Swedish Work Organization Matrix

Researchers in Sweden also developed an elaborate instrument, the Work Organization Matrix (WOM), for imputing job title averages of job characteristics to study subjects.[4,38,50,51] It is based on questions from the nationally representative Level of Living surveys administered in Sweden in 1977. The WOM is not directly related to the JCQ and has only two items on job demands. However, its work-control scale includes some questions that go beyond task-level influence, and ask about influence over selection of supervisor and coworkers, and planning of vacations. As in the JCQ, internal consistency values are higher for the work-control scale (α = .75) than for the psychological job-demands scale (α = .60).[50] The response format is "yes/no" for the job-demands items and "often/sometimes/never" for the work-control items.

Whitehall Job Characteristics Questionnaire

Researchers conducting the Whitehall study of British civil servants adapted the JCQ for their study[13] by adding questions on decision authority and changing to a response format based on frequency (a 4-point scale ranging from "often" to "never"). They found higher internal consistency for their job-control scale (α = .84) than for the job-demands scale (α = .67). A slightly shorter version of the Whitehall questionnaire has been used by researchers in the Copenhagen Heart Study.[74]

To obtain the Whitehall Questionnaire: Dr. Amanda Nicholson, Department of Epidemiology & Public Health, University College London, 1-19 Torrington Place, LONDON WC1E 6BT, Tel 0171-391-1684, e-mail amandan@public-health.ucl.ac.uk

Effort-Reward Imbalance Questionnaire

The effort-reward imbalance (ERI) model of work stress expands some of the concepts described in the previous questionnaires (see Table 1). Siegrist, et al. define threatening job conditions as a "mismatch between high workload (high demand) and low control over long-term rewards."[92] *Extrinsic effort* is defined very similarly to job demands in the JCQ, DCQ, WOM, and Whitehall, although in some studies it includes piecework and shiftwork. Low *reward* refers to low "esteem reward" (similar to lacking social support), low income, and poor job security/career opportunities (i.e., layoffs, undesirable change, poor promotion prospects, and work not adequately reflecting education level [status inconsistency]).[91,92] Response options in the current version of the questionnaire are "agree" or "disagree," and if "agree" is chosen, the level of distress—ranging from "very" to "not at all" on a 4-point scale—is requested. The internal consistencies of the extrinsic effort scale (α = .76) and the reward scale (α = .81–.82) are good.[82,104]

The ERI model emphasizes broader aspects of job control than the JCQ, DCQ, WOM, or Whitehall questionnaires. However, Karasek and Theorell's model was not intended to restrict the concepts of demands and control to task-level measures.[54] The core JCQ and the DCQ were derived from specific U.S. and Swedish surveys and therefore created post hoc. However, the full JCQ contains items and scales that measure income and aspects of low job security/career opportunities.[56] Roughly 9 of the 14 concepts employed by Siegrist and Peter to measure extrinsic effort and low reward are contained in the JCQ.[91] Many researchers have chosen to use only two of the core JCQ scales (14 items measuring decision latitude and workload demands) due to limited space and time constraints; however, the full JCQ includes a broader set of measures. In addition, the *life course perspective* of work task control developed

by Johnson using the WOM [Johnson, 1996] reflects job security/career opportunities.[96] In a study of Swedish men, dichotomous measures of ERI and job strain were mildly correlated (r = .21).[79]

To obtain the ERI questionnaire: Johannes Siegrist, e-mail siegrist@uni-dusseldorf.de

OCCUPATIONAL STRESS INDEX

The Occupational Stress Index (OSI) incorporates essential elements of the job demands-control model, as well as other formulations of how stress leads to CVD, such as features of work in high-risk occupations.[9–11,21,22] The OSI is reflective of a cognitive ergonomic-neurophysiologic approach (see Chapter 3). The factors are organized into a two-dimensional matrix with the stress dimensions (underload, high demand, strictness, extrinsic time pressure, noxious physical exposures, threat-avoidant characteristics, and conflict/uncertainty) along the horizontal axis. The levels of human information transmission—sensory input, central decision-making, and task execution—plus a general level, form the vertical axis.[107] Thus, each factor has a set of coordinates, localizing it to the type of stress and the level at which it affects the worker. The OSI contains 58 items, including more specific questions than standard job stressor questionnaires, and thus can be useful as a diagnostic tool for intervention strategies. For example, the OSI operationalizes the specific elements that contribute to psychological demand and thus can discriminate professional drivers from control subjects (building tradesworkers and subway guard attendants); job demands-control measures (e.g., DCQ) often cannot.[8] In addition to the general OSI (Cronbach's $\alpha = 0.81$), a version specific to professional drivers has been developed (Cronbach's $\alpha = 0.84$),[9] and an OSI for physicians is being developed. Each of the seven subscales of the OSI have shown acceptable internal consistency reliability (see Table 2), with the exception of "strictness" and "extrinsic time pressure." The OSI also emphasizes stressful aspects of work that have disaster potential or "life and death" consequences, such as are experienced by professional drivers, air traffic controllers, healthcare workers, and sea pilots. Response options vary, but are usually on a 3-point scale, and include intensity and frequency.

To obtain the OSI: Karen Belkic, Center for Social Epidemiology, Room 202, 1528 6th St., Santa Monica, CA 90401, 310-319-6595, e-mail kbelkic@hsc.usc.edu

OTHER MEASURING TOOLS

The NIOSH generic job stress instrument also contains items on cognitive demands, role conflict, role ambiguity, responsibility for people, and threat of violence or injury.[72] Jackson and colleagues have examined monitoring demands (e.g., undivided attention, keeping tract of processes, concentrating all the time, reacting quickly to prevent problems arising), problem-solving demands, and production responsibility. Some researchers have suggested adding "emotional demands" (items about death, sickness, human suffering, aggressive and awkward patients or clients).[12,17] Borg and Kristensen, in Danish national studies also have examined sensorial job demands (attention, need for precision, intensity), cognitive demands, and the demand for suppressing one's emotions.[12] However, none of these studies have examined CVD outcomes.

Jackson, et al. differentiate control over scheduling/pacing of tasks ("timing control") from control over the process by which tasks are performed ("method control").[45] In addition to expanding the concept of job control to work group or organizational

policies or procedures (as in the full JCQ or the NIOSH questionnaire) and to long-term job security/career opportunities (as in the ERI), the full JCQ begins to measure aspects of job control exercised collectively.[47] Such collective control, e.g., through a union collective bargaining agreement, may be an important means for employees (particularly lower socioeconomic status employees) to exercise task control, increase income, achieve job security, improve promotion prospects, and minimize undesirable change.

The JCQ, DCQ, WOM, ERI, OSI, and NIOSH instruments also contain questions on physical demands and hazardous physical or chemical exposures. The association of these characteristics with job strain or ERI rarely has been examined and, in fact, may confound or modify the effect of job strain on CVD risk.

To obtain the NIOSH questionnaire: Joseph J. Hurrell, Jr., NIOSH Division of Surveillance, Hazard Evaluations and Field Studies, Mail Stop R12, 4676 Columbia Parkway, Cincinnati, OH 45226, 513-841-4428, e-mail jjh3@NIOSHE1.em.cdc.gov

Formulations of Job Strain

Job Demands and Job Decision Latitude. The interaction between job demands and job decision latitude, which defines job strain, has been operationalized primarily in four ways.[64,84] (1) The most common procedure applies a quadrant approach, identifying employees who are above the median on demands and below the median on latitude as "high strain". The determination is made by dichotomizing self-reports of demands and latitude at either the sample medians or national medians/means. (2) A newer approach (used in seven studies with positive results[64,84]) creates a continuous, independent variable—demands divided by latitude. (3) Eight studies have employed a multiplicative interaction term partialled for main effects (demands × latitude, controlling for demands and latitude). However, the interaction term significantly improved the variance explained by the model beyond what could be obtained with only the main effects in only four of those studies.[37,39,48,64] (4) Exploratory graphical approaches examine interaction effects and thresholds (nonlinear effects). For example, demands and latitude have been divided into tertiles or quartiles, and patterns of heart disease risk examined across the resulting nine[48] or 16[52] exposure cells.

Main effects often were not reported in the studies utilizing quadrant or quotient terms. (A number of studies have examined the main effects of job demands and job decision latitude, finding some significant associations.[84]) Therefore, we cannot determine whether such formulations model interaction or the sum of two main effects. In the Cornell Work Site Blood Pressure Study (WSBPS), all four formulations of job strain were significantly associated with elevated ambulatory SBP, and the quadrant term was a significant predictor of SBP controlling for the main effects of demands and latitude. However, associations with DBP and risk of mild hypertension appeared to be more appropriately modeled as the sum of two significant main effects.[64] True interaction effects frequently are difficult to detect due to a lack of statistical power.[55,83]

Thresholds. If a population threshold exists for the effect of job strain, the proportion of subjects exceeding this threshold typically varies across nonpopulation based samples. For example, if only 10% of a given sample is experiencing "high" (biologically relevant) job strain, but 25% is classified as "high strain" using the quadrant definition, misclassification and a dilution of the effect estimate occurs. One approach for exploring possible thresholds, or nonlinear or nonmonotonic dose-response curves, is to dichotomize a continuous exposure variable at various points

and plot the resulting odds ratios or mean differences.[106] In the Cornell WSBPS, a significant effect of job strain (using the demands/latitude quotient term) on work and home ambulatory BP was seen at cutpoints beginning at about the upper tertile of the distribution of job strain, and this effect increased in magnitude as the cutpoints increased. Another strategy used in the Cornell study was to define as high strain the group defined by the lowest tertile of decision latitude and the highest tertile of demands (6.5% of the sample). This group had work SBP about 10 mmHg higher than those in low demand or in high latitude groups. Using national means for decision latitude and demands to define the high strain group (8% of the sample) also resulted in larger effect sizes, 11.5 mmHg SBP and 4.1 mmHg DBP. Therefore, in this sample, there was evidence of both a threshold of effect for job strain, and increasing effects at higher levels (or "doses") above the threshold.[64]

Social Support. Workplace social support has been examined in conjunction with the job strain model in several studies of CVD. Some evidence exists for a social support main effect,[23,48] although null results also have been reported.[4,6,51,69] Some studies have found an interaction—a buffering by social support of the effects of job strain.[6,23,58,51] A third approach, used in one study with positive findings,[49] does not try to disentangle main effects and interaction, but simply hypothesizes that socially isolated, high-strain work ("iso-strain") carries the highest risk. This approach was proposed since iso-strain is a univariate measure, "a more parsimonious instrument for measuring and analyzing workplace conditions."[49]

Cumulative Exposure. In most studies, exposure to job strain was measured at only one point in time; thus, the effect of duration of exposure could not be assessed. *Current* exposure may be an inadequate measure of *cumulative* exposure since people gain skills with time and age, may be promoted, or may select out of high strain jobs. (In the U.S. QES there is evidence of an inverse association between age and job strain.) In the first 3 years of the Cornell WSBPS, test-retest reliability of the decision-latitude and job-demand scales was fairly high (both $r = 0.64$). However, 22% of participants changed their (dichotomous) job strain status in 3 years—resulting in a more than 50% turnover in the initial high-strain group. Therefore, complete work histories were collected from Cornell study participants. Six questions from the JCQ were asked about each past job held by 379 study participants. Internal consistency of the three two-item scales was high for workload demands ($\alpha = .81$), but borderline for job decision latitude ($\alpha = .62$) and workplace social support ($\alpha = .63$). Two items were added to increase the reliability of the latitude scale. Among the 255 participants who answered all four latitude items, scale reliability increased to $\alpha = .83$. In preliminary analyses, job strain during the 5 years prior to Time 1 is associated with Time 1 work and home SBP among men > 44 years of age and men with ≤ 14 years of education, independent of Time 1 job strain. For example, men > 44 years of age who report job strain at Time 1 *and* job strain during at least 3 of the 5 years prior to Time 1 have ambulatory SBP about 14 mmHg higher than men with neither exposure. The measure of job strain during the past 5 years had a modest association with Time 1 job strain (kappa = .24).

Johnson, et al., using the Swedish WOM, found that low work control, in each 5-year cumulative exposure interval over the past 25 years, was associated with significant elevations of risk of CVD mortality among Swedish men, with relative risks ranging from 1.6 to 1.8.[51] However, exposure > 25 years was not associated with increased mortality, implying an induction period of 25 years or less.

IMPUTATION OF JOB CHARACTERISTICS SCORES

by Joseph Schwartz, PhD

Many datasets contain rich health information, but lack details about subjects' job characteristics or work situation. An example is the U.S. National Health and Nutrition Examination Surveys (NHANES), which provide physical exams to large numbers of individuals, and panels of experts adjudicate individual cases with respect to the presence or absence of a variety of diseases and conditions, including MI. It would be unfortunate if there were no way to use such studies to examine the relationship of working conditions and health.

Fortunately, most large health studies do contain information on a variety of related demographic characteristics, including participants' education, employment status, occupation, and, sometimes, industrial sector. There is a long tradition in sociology of using occupation to rank individuals along a hierarchical dimension of social status or prestige.[20,24,41,42,71,90] As a result, if a survey includes information on participants' occupations, coded according to a standard classification scheme such as that used by the U.S. Census, it usually is a straightforward process to translate the occupation codes into a measure of social status. While this has been useful for addressing questions pertaining to the relationship of socioeconomic status to health or disease, it has only marginal utility for addressing questions concerning the specific factors about work that may put individuals at increased risk for cardiovascular or other diseases. The ability to infer decision latitude, psychological job demands, and other specific characteristics on the basis of occupation would be helpful.

At least four linkage systems allow assigning of scores on a variety of job characteristics to individuals on the basis of their occupations. The oldest is based on the **Dictionary of Occupational Titles** (DOT).[100,101] Department of Labor experts defined 12,099 job titles and rated each according to 44 characteristics, subdivided into seven broad categories. Three "worker functions" summarize the job's complexity with respect to data (or information), people, and things (equipment). There are two measures of the average level of training required, one for general education and the other for specialized vocational training. Eleven skill areas, ranging from general intelligence to finger dexterity, are rated in terms of the amount required to perform the job at an average level. Ten temperaments describe various characteristics of jobs that workers may have to accommodate to; these include influencing others, repetitive or continuous tasks, performing under stress, and variety or change. Jobs are also rated in terms of five bipolar "interests," identifying which of two extreme preferences that an individual might hold would be more consistent with the job; for example, a preference for abstract/creative activities versus routine/concrete/organized activities. Finally, jobs are rated with respect to physical demands (six characteristics) and physical environment (seven characteristics).

The primary goal of the DOT has always been to facilitate the matching of workers to jobs by employment offices. Spenner was the first to use the detailed job titles to estimate the average characteristics of each three-digit census occupation category and suggest that these be linked to other datasets and used for research purposes.[94] Subsequently, the DOT variables were linked into one of the U.S. Census Bureau's nationally representative Current Population Surveys (n = approximately 55,000) using detailed job titles, and then the means of the 44 job characteristics for each 1970 census occupation category were computed. Using the resulting database (available from the Inter-university Consortium for Political and Social Research), it is possible to merge the occupation means into any existing dataset containing 1970

census occupation codes. Miller, et al. provide a thorough review of the strengths and weaknesses of the DOT.[70] No one has ever investigated the ability of these scores to predict CV functioning or disease.

The second linkage system was developed by Schwartz, Karasek, and Pieper[87] and is closely related to the **Job Content Questionnaire**. Using identical, or nearly identical, questions administered to three random samples of the U.S. labor market in 1969, 1972, and 1977 (Survey of Working Conditions, 1969; Quality of Employment Surveys, 1972, 1977[80]), eight subscales were constructed. These became the core of the JCQ.[56] Pooling the three surveys resulted in combined samples of approximately 3000 men and 1500 women. After combining some of the smaller census occupational categories, occupation-level means of the subscales were estimated and linked to the National Health Interview Survey and NHANES I study.* The analyses of the linked data were the first to document an association between job strain and MI prevalence in U.S. males.[57]

The third and fourth linkage systems were developed in Sweden. The first[3] is similar to that of Schwartz, et al. Employed male respondents to a national random sample of households rated their jobs on a number of psychosocial factors, including amount of overtime, shift work, hectic or monotonous pace, influence over work pace, contact with coworkers, and opportunity to learn new things. Responses to each question were dichotomized and the percentage of positive responses in each occupational group (n = 118 occupations, based on the Nordic version of the three-digit International Standard Classification of Occupations) was determined. Occupations were then classified as either having or not having each characteristic based on whether the proportion of positive responses (from individuals in that occupation) exceeded 50%. When these dichotomous occupation scores were linked to the 1970 or 1975 occupations of a sample of individuals who were born 1911–1935 and died 1974–1976, those individuals whose occupations were classified as hectic *and* providing either little influence over work pace or lack of opportunity to learn new things were 35–45% more likely to have died from MI.

The second Swedish linkage system was developed by Johnson and colleagues.[50] Using the responses to a random sample of the employed Swedish population (n = 12,084), scales measuring work control, psychological job demands, social support, physical demands, and exposure to hazards were constructed. As in the other linkage systems, the mean score for each scale was computed for each occupation (n = 261). This system was the first to be applied to work history data to assess the relationship between CV mortality and cumulative exposure to work-related psychosocial factors; low work control, especially in combination with low workplace social support, was associated with an increased risk of CV mortality.[51] In other studies, low work control was associated with incident MI in middle-aged men[99] and in both men and women.[38] For men in the latter study, the combination of low work control, high psychological job demands, and low social support was associated with the highest risk.

Occupation-based linkage systems for imputing psychosocial work characteristics have both advantages and disadvantages relative to the more common self-report questionnaires. The ability to impute or infer work characteristics to existing

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* A second, parallel linkage system imputes job characteristic scores using not only an individual's occupation, but also several other demographic characteristics: education, age, race-ethnicity, marital status, and whether self-employed. Scores based on the two linkage systems are highly correlated. Separate linkage systems were developed for men and women.

datasets that contain information about subjects' occupations, but little or no information about other work characteristics, is beneficial. The other major advantage is that imputed scores are much less susceptible to self-report bias. First, they are based on the average of several self-reports; thus, individual biases tend to cancel each other out.* Second since linkage systems almost always are applied to datasets other than the one from which they were generated (for an exception, see Johnson and Stewart, 1993), the individuals who provided the self-reports are not the individuals in whom the relationship between health and work characteristics is assessed. This rules out the possibility that an observed relationship is due to **reverse causation**, such that those with a particular health condition are more likely (as a consequence of their disease) to report, for example, having less decision latitude or more job demands. The primary threat to the validity of an observed association is the possibility of **self-selection**, that those at higher risk (due to nonwork-related factors) are more likely to enter particular occupations. Of course, concern about selection bias is at least as applicable to findings from self-report data as to findings based on imputed work characteristics, and the goal of both types of analysis should be to try to statistically control for those nonwork-related risk factors that might influence occupational selection.

An additional strength of these linkage systems is that they are based on moderately large (1500–3000) to very large (> 10,000) representative national samples of the labor force. The representativeness of the original samples is critical to the validity of imputing job characteristics based on the occupation means in one sample to individuals in another sample. Another factor is the sample size of each occupation. Not surprisingly, the sample means of those occupations with more individuals are more accurate estimates of the occupations' true means than are the sample means of smaller occupations; the estimated precision of each sample mean is inversely proportional to the square root of the number of individuals in the sample with that occupation. Thus, most of the linkage systems do not impute means for those occupations for which the "parent" survey has fewer than three[3,87] or five[50] incumbents. Still, those occupation means that are based on 40 individuals will be twice as precise as those based on only 10. The degree of imprecision due to sampling variability, as reflected in the standard errors of the occupation means, is comparable to unreliability in multi-item scales and limits the generalizability of the estimated occupation means when they are imputed to other samples from the same population and time period.

Equally critical is the generalizability of the occupation means to other populations, subpopulations, or cohorts. These linkage systems have not been applied outside their country of origin, but they have been applied to geographically defined subpopulations[38] and to occupations held by individuals more than a decade before or after the occupational information was collected.[51] It is not clear to what extent the average work characteristics of an occupation in the mid-1970s reflect the characteristics of that occupation in the early 1990s; certainly some occupations have gone through substantial transformation while others have remained relatively stable. This issue is particularly important when a linkage system is applied to complete work histories to estimate cumulative exposure to hypothesized putative factors. In

* The possibility of a collective bias (or subjective perception) in the self-reports of individuals within specific occupations, based on shared experiences, professional organizations, and perhaps culture (e.g., police, skilled trades), cannot be ruled out. Such collective biases, to the extent they exist, are likely to be reflected in the occupation means of each of the linkage systems described above.

this situation, the same work characteristics are imputed to a job regardless of whether it was held during the 1950s or the 1980s.

The DOT-based linkage system is based on expert evaluations of occupations, performed by employees of the U.S. Department of Labor, while the other three linkage systems are based on self-reports of individuals in each occupation. The latter offers greater knowledge, but potential subjectivity. The expert observer's understanding of the work situation is more superficial because it usually is based on a limited period of observation. However, experts may be in a better position to make comparative assessments of jobs/occupations, due to training and experience of observing many jobs. They may be able to apply rating scales in a more consistent fashion than a set of individuals who each rate only their own job.

Certainly the greatest disadvantage of linkage systems is that they cannot characterize any of the variability among jobs within an occupation. All individuals in the same occupation are assigned identical scores for each job characteristic. This implicitly ignores all within-occupation heterogeneity, and certainly there is substantial variability among the multitude of jobs that are aggregated into one occupational category. Some of these differences are related to the company, specific supervisor, or coworkers, and maybe even characteristics of the incumbent. For example, a given job is likely to be less psychologically demanding for someone who is highly skilled and/or has cooperation and support from coworkers.

EXPERT-OBSERVER ASSESSMENT OF JOB CHARACTERISTICS *by Birgit A. Greiner, PhD and Niklas Krause, MD, PhD*

A growing number of studies, including longitudinal studies, consistently show associations between occupational stressors and CVD morbidity and mortality. However, it is not clear to what extent the characteristics of the job or the individual's interpretation of the job situation, based on factors such as coping strategies and personality, contribute to this association, because stressors are usually measured by self-report. To disentangle the effects of the person from the effects of the job environment, it has been suggested that stressors be measured by different methods within one study.[26,33,60,89] For example, Kristensen suggested a "triangulation strategy" for CV research using self-rated measures of each individual, average measures (all workers with the same job title are given the average values of responses provided by workers with this particular job), and independent measures of job characteristics, (e.g., assessments by external experts).[60]

To date, most studies on CVD and work stressors are based on either **individual self-ratings** of the worker, or on the **average method** as a strategy to minimize the variation caused by individual differences. Schnall, et al. report that the average method usually yields lower associations between job strain and CVD than the individual self-ratings.[84] Does the individual appraisal of stress factors contribute more to the stress-health association than the actual work conditions? Such a conclusion would be premature, since the use of average measures based on job titles introduces a methodological problem that biases the association toward the null. Most occupational titles are crude, covering not only a wide range of occupations with different stressor levels but also a wide range of organizational settings that might affect stressors within even a single, narrowly defined occupation. A third method is the use of self-reported data averaged over several workers on the level of a particular job

within one company—the **shared job strain concept**.[89] Averaging individual stressor measures within only one company ensures that measures apply to the same job and the same organizational setting. This method appears especially suitable for simple, blue-collar jobs in large companies where exactly the same task exists more than once. However, this method might be difficult to apply at the white-collar level due to a lack of identical jobs within one company.

Another measurement approach to minimize variation caused by the individual is the **external assessment** of working conditions. The advantage of such measures is that they are (ideally) not confounded with the personality of the worker, and the specific organizational setting of the job, as it affects job characteristics, can be taken into account.

Methods for External Assessment of Job Characteristics

Each method has a specific strategy for measurement "objectivization," intended to minimize or eliminate distortion of job characteristic data by individuals:

1. Archival data from company or insurance records. Objectivization is achieved by the *nonreactivity* of the measurement. Bias caused by worker reactivity to the measurement is excluded. However, the interpretation of archival data is limited, because the data usually provides only crude indicators of stress factors, which often are restricted to a specific occupational group (e.g., traffic density as a measure for demands in bus drivers, or number of incoming phone calls as a measure of demands in telephone operators). Additionally, archival data usually is collected for practical rather than scientific purposes; thus quality is limited due to inconsistent coding, lack of check for data entry mistakes, and empty data fields.

2. Assessment by external experts without inspection of the individual workstation. There is presently no widely accepted method for this assessment. In studies of state employees in England, experts have rated job conditions with regard to the crucial dimensions in the demand-control model (DCM).[76] Others used expert ratings based on the U.S. Dictionary of Occupational titles.[1,70a] The measurement objectivization of this method is achieved by benefiting from the knowledge of experts over a wide range of occupations, which *minimizes personal bias*. This method has the same limitations as the average method, due to the crude definition of job titles and the variety of organizational settings.

3. Supervisor or coworker assessments of individual jobs. Objectivization results from relying on the direct experience of supervisors and coworkers.[5,76,93,108] In this method, supervisors and colleagues serve as *quasi-observers* of *day-to-day working conditions*. The validity and reliability of such measures might be highly dependent on the closeness of the supervisors and colleagues to their subordinates and coworkers and their familiarity with the jobs to be rated. For example, North, et al. reported only moderate agreement between two supervisors rating the same job who were not the immediate supervisors.[76]

4. Worksite observations conducted by trained observers. This assessment occurs during regular working hours in the tradition of job analysis.[46] Actual job behaviors and working conditions are measured in *real time*, rather than retrospectively as in self-report. Observations can provide detailed quantitative and qualitative information about individual work tasks within different organizational settings, thereby allowing description of those workplace factors requiring modification to reduce stressors. Limitations of this method include nonobservability of mental processes; the restricted observation period, which makes the identification of rare events difficult; and the temptation for observers to base their ratings on worker behavior rather than on characteristics of the environment.[26]

Regardless of these potential biases, the interpretation of any type of expert rating is limited if different experts do not refer to the same concept about stress factors, but instead apply their individual concepts. If they do not have a mutual underlying theory, the same measurement problem that affects self-reports is transferred from the worker to the expert.

5. Theory-guided observational interview. This is a variation of worksite observation that might minimize bias.[77] It is performed at the worksite by an analyst who is trained in the application of the theoretical framework. (We avoid the term "observer" because the observational interview consists of more than just observation.) The analyst is the agent of the measurement objectivization by serving as a "translator" for observations and self-reports, and theory and definitions. Questions of the instrument are worded in expert language and addressed toward the analyst. The advantage of expert language, versus colloquial language used in self-reports, is that it can be more precise and can minimize subjective interpretation of the analyst. In theory-guided interviews, analysts are not restricted to obtain the necessary information by worksite observation only, but also can use self-reports and archival data (e.g., work schedules). In this method, the strength of *observational techniques* (real-time assessment) and *structured interviews* (worker as the expert of his/her job) and the advantage of *archival measures* (nonreactivity of measurement) can be combined. Observational interviews can gather information that is not available by observation alone, and information that is likely to be missed during the observational period (rare events) can be included in the analysis.

There is no commonly agreed upon procedure, and only a few theory-guided observational instruments have been developed and validated in epidemiologic studies with explicit health outcomes. One challenge for the development of these instruments is their applicability to a range of different occupations. This goal excludes the use of simple stressor event checklists, which usually are applicable only to narrowly defined occupational groups. Instead it requires the use of theoretical concepts that allow for a common definition of stress factors in a range of different jobs.

Theory-guided interviews have been used in CV research.[30,95] The job analysis instrument RHIA/VERA, used in a multimethod approach in CVD research[30] and in studies with other health outcomes,[32–34,61,65,68] is described on the following pages.

The Theory-Guided Observational Instrument RHIA/VERA

There are two tested versions of this instrument in German—one for blue-collar work[67] and one for white-collar work[66]—and an English version for the assessment of job characteristics in transit driving jobs.[31] Currently, a shortened version of the RHIA/VERA method is being used to assess the job characteristics of a subsample of the Whitehall Study.[29] Interrater reliability coefficients are very good for most dimensions.[33,34,66,67]

THEORETICAL BASIS AND DEFINITIONS

The theoretical basis is Action Regulation Theory. This theory conceptualizes psychological processes important for human action, such as planning, thinking, deciding, and motor regulation, in interaction with the environment.[25,35,36,102] Applied to the work situation, the unit of analysis is not the individual worker but the task—more precisely, the **mental structure of the work task**. This structure comprises the mentally regulated operations by which the worker carries out a job.

Two main dimensions for the analysis of work are assessed: level of requirements for skill utilization and work hindrances. The model conceptualizes hindrances as factors that potentially impair health, whereas high levels of skill utilization promote health and personality development.[19] Studies using the RHIA/VERA instrument show that hindrances are associated with impaired physical health or health complaints, whereas skill utilization is more strongly associated with mental health and active leisure-time activities.[65,68]

The **level of requirements for skill utilization** is defined as the degree of independent thinking, planning, and decision-making that is required from the worker to carry out the task. The instrument includes a 10-level scale with defined categories (Table 3). The lowest level of skill utilization is the application of preset rules without any latitude for independent thinking or planning. Medium levels require one or more decisions of the worker; high levels include complex strategy decisions that affect other workers. To categorize the task into one of these levels, the analyst has to become familiar with the content of the task as a first step of the analysis.

Hindrances (or stressors), the second main dimension, are defined as characteristics of the work task that hinder the action regulation processes due to poor technical or organizational design. The underlying cause of stressors is seen in restrictions of worker control, or "partialized" work.[77] Conditions are not considered stress factors if workers have the control to remove the hindrance so that it will not reappear in the future. Subdimensions of hindrance include work barriers, time pressure (a measure of the work pace), time binding (a measure of worker control over time handling), and monotonous conditions.[34] The main subdimension is *work bar-*

TABLE 3. Synopsis from RHIA/VERA Instrument for White-Collar Work: Levels of Skill Utilization

	Level 5 Introduction of New Work Processes
5	The worker is responsible for organizing conditions for the introduction of new work processes. Existing work processes *have to be combined* in a new way.
5R	The worker is responsible for organizing conditions for the introduction of new work processes. Existing work processes *are not changed* in a major way.
	Level 4 Coordination of Work Areas
4	The worker has to make at least two *strategy decisions* in areas of others and has to coordinate them.
4R	The worker has to make at least two strategy decisions and take strategy decisions in work areas of others into account without changing them.
	Level 3 Strategy Decision
3	The worker has to make *one strategy decision*, that is a plan about what needs to be decided. From there it is clear what needs to be done next.
3R	The worker has to make *more than one decision* within one work assignment.
	Level 2 Decision
2	Before or during the processing of an assignment the worker has to make *one decision*.
2R	It is necessary to *visualize* the work procedure before starting or during executing the assignment.
	Level 1 Rule Application
1	For processing of the assignment the *recognition* of the externally determined procedure is necessary.
1R	The assignments are always done in the same way with the same work means. The procedure is *fully externally determined.*

From Greiner B: Work analysis instrument to measure objective work stressors and skill utilization in white-collar work: RHIA-VERA, shortened version. (Original version by Leitner K, Lueders E, Greiner B, et al, Technical University of Berlin, 1993.) Translated from the German, edited, and revised by B. Greiner. Greifswald, University of Greifswald, 1999.

riers, defined as obstacles that hinder work performance. Barriers create a dilemma for the worker: the worker is required to perform the job a certain way, but the technical or organizational design of the job impedes performance. If this dilemma is associated with objective negative consequences for the worker, such as extra work or unsafe behavior, then, by definition, work barriers constitute a stressor. Barriers can be caused by technical or ergonomic problems, lack of tools or supplies, difficulties regarding the flow of work information, environmental factors, and organizational problems. These problems are not considered stressors if the worker is given partial or full control over them by the company, (for example, if the worker is explicitly allowed to lower the quality of work or to postpone deadlines without additional effort when the problem is present).

OVERLAP WITH THE DEMAND/CONTROL MODEL

Although based on a different theoretical background, the stressor dimensions described above overlap with the dimensions of the DCM. Barriers correspond with the "high-strain quadrant" in the DCM. They are conceptualized as work obstacles that require extra work and, therefore, put additional demands on the worker without the opportunity for efficient control. In contrast to the DCM, demands and control are not documented as two distinct dimensions in the assessment of barriers. Instead, the analyst evaluates each demand that could potentially constitute a barrier whether or not the specific demand can be controlled efficiently. In this way, the contextual factors that restrict control can be determined and described on a highly detailed level, helpful for job redesign. The concept of time pressure is comparable to the demand concept, especially to the aspect of work pace.

Thus, the RHIA/VERA approach provides a more differentiated picture than the Job Content Questionnaire via two dimensions: work barriers, as high demands that are posed on the worker due to work obstacles, time pressure, as a measure of work intensity under regular conditions due to an excessive amount of work per time unit. The dimension of skill utilization corresponds to the "learning axis" in the DCM that assumes a learning and personality development potential for the worker if he or she does work with high latitude.[54]

MEASURES OBTAINED

The analysis results in five quantitative measures.[34] Three measures reflect absolute numbers expressed in minutes per working day or week (work barriers as summary measures of extra work minutes spent to compensate for the obstacle, time pressure in minutes of detachment time, monotony in minutes of presence of this condition). Two measures are derived from scales with defined categories (time binding on a five-level scale, skill utilization on a 10-level scale). Rating scales (e.g., Likert scales) are not used to minimize the bias of subjective interpretation of the analyst. Furthermore, a detailed description of the task, stress factors, and skill utilization factors, and suggestions for work redesign to reduce stress (e.g., by increasing the decision latitude or other organizational solutions) are obtained.

PROCEDURE: THREE-PHASE MODEL TO OBSERVATIONAL INTERVIEW

The RHIA/VERA job analysis instrument provides the analyst with a protocol for interview and observation that includes definitions of work stressors and skill utilization, stressor classification, and stressor and skill utilization evaluation and quantification (Table 4). (1) In the **descriptive phase**, the observer describes in detail the required work result and work steps to achieve the result, including motor

TABLE 4. Three-Phase Assessment Model of the RHIA/VERA Procedure

Phase	Part of the Instrument	Function
1: Orientation		**Describe task, contrast with available resources**
	Work result: describe expected quantity and quality standards of work result; observed deviations from standards	Deviations from expected standards might indicate stress factors (time pressure or work barriers)
	Work means (resources): describe equipment, machinery, tools, technology, and work information used to accomplish task; use of resources	Contrast expected work result with available resources; determine potential barriers related to lack of resources
	Work context: count and describe potential barriers due to interruptions	Potential barriers are tested later in analysis—whether they are "true" barriers
	Work steps: describe sequence of steps necessary to accomplish task	Describe mental structure of task to determine stress factors and skill level
2: Reflection		**Detach from worker, objectify information, develop focus points**
	Identify missing or contradictory information: summarize information obtained during Phase 1	Helps analyst focus observational interview in evaluative phase and probe worker
	Indications for stressors: follow guidelines to formulate hypotheses about potential stress factors for each work step (tested in Phase 3)	Specific hypotheses about potential stress factors help analyst focus observation
3: Evaluation		**Describe and quantify stress factors and skill utilization; suggest work redesign**
	Skill utilization: definitions of levels and standardized questions for classification	Classification of task into one of 10 sub-levels
	Classification of barriers: provides definitions of different types	Potential barriers classified
	Barrier test: standardized questions to determine whether potential stress factors are "true" stress factors	Potential barriers rated if are barriers according to theoretical definition
	Summary of barriers: procedure to describe barriers and potential technical/organizational solutions, and to estimate frequency of barrier and duration of extra work	Description and quantification of barriers
	Time-binding: rating based on observed (and archival) information on a five-level scale	Quantification of time-binding
	Monotonous working conditions: standardized questions to determine whether monotonous conditions exist; for how long during task performance	Quantification of exposure to monotonous working conditions
	Time pressure: detachment periods are subtotaled; time saved by neglecting safety and quality standards and working overtime is subtracted	Quantification of time pressure

processes as well as decision and thinking processes (mental structure of the task). This is contrasted with a description of provided resources to achieve the result—such as hardware, software, machines, tools, and access to necessary information—and with contextual factors that might interfere with task performance, such as

interruptions by persons and phone calls. (2) In the **reflective phase**, the information obtained by observation and interview is objectified. This requires the analyst to detach from the social situation with the worker by interrupting the observation for 30–60 minutes. During this period the analyst reflects on the obtained information, "translates" it into the concepts and definitions given in the observer manual, determines the missing pieces of information still to be gathered, and evaluates if the task can be done in the required way considering the available resources and the contextual situation. At the end of this phase, the analyst develops hypotheses about concrete stress factors to focus additional observations and questions. (3) In the **evaluative phase**, the analyst identifies, describes, and quantifies the hindrances and skill utilization factors. Discordance between observed and self-reported information may need to be probed and dissolved during the evaluative phase.

Multi-Method Approach in CVD Research

The RHIA/VERA method was used together with self-report measures in a study of hypertension in urban transit operators in San Francisco.[30,34] This occupational group is particularly interesting for studies on stress and BP for two reasons: they are a high-risk group for CVD morbidity and mortality,[58,81] and there have been several unexplained results in this group. For example, Netterstrom and Suadicani reported an excess risk of IHD for bus drivers in Denmark with low exhaustion and high job satisfaction and drivers who reported high variation in their job,[75] and Winkleby found an inverse association between self-reported stress and hypertension in the same San Francisco transit operator population.[109] (These unexplained findings have been attributed to possible distortions due to the use of self-report stressor measures. One potential explanation might be that individuals who cope with stress by denial underestimate stress factors. These individuals might be at high risk for hypertension.)

For a subsample of the San Francisco Transit Operator Health and Safety Study (SFTOS), a multimethod design was applied that included both self-report (perceived strain; stress factors) and job characteristics (stress factors) assessed by observational interview. The externally assessed measures were averaged on the level of the transit line across individuals, and self-report strain and stress factors were used on the level of the individual and on the level of line-specific average measures. There was a significant gradient between externally assessed barriers and hypertension and between externally assessed time pressure and hypertension after adjusting for several potential confounders.[30] This finding suggests validity of the externally assessed measures. Neither of the self-report measures (strain and stress) predicted hypertension. Averaging self-report measures for identical jobs (in this case identical transit lines) to cancel out individual variation did not substantially improve the association to the health outcome. The hypothesis that individuals who rate high on the externally assessed stress factors but low on self-report stress factors (possibly due to denial) were at the highest risk for hypertension was not confirmed. However, the sample size available to test this interaction was small.

Four general methodological issues can be researched with such a multimethod study. The first issue concerns the association between self-report stressor measures and externally assessed measures. In the SFTOS, associations between the externally assessed and self-report measures were low to moderate. Similar results were reported by others using supervisor ratings[5,76] or observational data.[89,110] This might indicate that both general measurement approaches capture different aspects of stress factors, particularly for demands. The correspondence between the expert-rated or imputed assessment and the self-reported estimate of different aspects of

psychological demands usually is poorer than the correspondence for decision latitude.[76,88,99] In a study that used expert ratings (determined by an occupational healthcare team) of 4000 employees in several companies in Stockholm, the correspondence between expert ratings and self-reports was highest for decision latitude; the self-reports explained approximately 30–40% of the variation in the expert ratings.[40] Zapf differentiated between job characteristics that are more or less observable, dependent on one's own affective reaction, and stable over time.[99]

The second issue concerns the pattern of associations between stressor measures and the health outcome. If only externally assessed measures are associated with the outcome, questions about the validity of the self-reports can be raised. Alternatively, such a finding might indicate that both measurement approaches capture different, valid aspects of stressors, and that the aspect assessed by external measures is truly associated with the outcome. The reverse might be true, if only self-report measures predict the health outcome. A finding of both measures predicting the outcome independently, e.g., in a common regression model, suggests that both are describing different aspects of stressors and each one is important for the outcome. For example, in the Whitehall Study, both supervisor ratings and self-reports of low job control predicted new events of CHD[14] and sick leave rate.[76]

The third issue concerns individual variation in self-reports and expert assessments. If measures are confounded by individual perception of the worker, stressor measures averaged over the same job should be more predictive than individual measures. In a study of German blue-collar workers, the concept of "shared job strain" as a latent variable was introduced.[89] Shared job strain comprises symptoms that two workers with the same job have in common. If they share some variance, then the common aspect lies in the job. Job stressors were estimated by self-reports of two workers and two independent observers as indicators. In this study, the importance of "objective" job stressors was confirmed. Four job stressors explained two-thirds of the variance of shared job strain, whereas the trait model, which included individual worker variation, was not as predictive.

The fourth issue concerns the importance of measuring different concepts of stress with the same method. Stress can be either conceptualized as a "stress factor" (the environmental source of stress), or as "strain," understood here as perception of the severity of the stress factor. The concept more predictive of health outcome can be determined by holding the assessment method constant.

Applicability of Multimethod Approaches

Several questions can be addressed by the parallel use of self-report and observational measures. The choice of the most suitable method for the external assessment of job characteristics—archival data, expert ratings, or observational interviews—depends on the research question, the nature of the job, and the sample. Observational interviews are time-consuming, and their use is recommended specifically for the following:

1. Researchers who are concerned about the validity of their self-report data and want to validate these data by contrasting them with other measures.[89] New information about work demands that are difficult to capture by self-reports is particularly helpful.[110] Validation by observational interview also may be necessary when social stereotypes about the stressfulness of particular jobs are likely to distort self-reports and coworker and supervisor ratings.

2. In studies with health outcomes potentially caused by repressive coping and denial (e.g., hypertension, alcohol abuse). Valid ratings for job characteristics might

not be obtainable by self-reports from individuals with predominantly repressive coping. Comparing observational with self-report data and analyzing individuals with high discordance between the two can be interesting.

3. In companies with a large number of equal work tasks. One or two observational interviews can be conducted per work task and the same value assigned to all workers with identical jobs. In this way, the sample size can be increased greatly with just a few interviews.

4. For studies about occupational grade level and CV health. The skill utilization dimension provides a highly reliable measure of the skill level objectively required for carrying out the job and of the learning potential provided by the job. Mismatches between the worker's skills and the required skill level can be determined.

5. If researchers want detailed analyses of potential organizational and technical causes of stress factors for intervention purposes. Observational interviews expand upon information obtained by questionnaire and provide a basis for job redesign strategies.

CONCLUSIONS AND RECOMMENDATIONS *by Paul Landsbergis, PhD, Birgit Greiner, PhD, Niklas Krause, MD, PhD, Joseph Schwartz, PhD, and Töres Theorell, MD, PhD*

It is important to determine whether it is primarily the objective characteristics of jobs or workers' subjective perceptions and evaluations of them (or both) that are most predictive of changes in BP or the development of CVD. This determination would allow more precise and valid theory and measurement, improving estimation not only of magnitude of effect, but also interaction, thresholds of effect, cumulative exposure, and induction periods—estimates which generally have had limited statistical power.

Self-report questionnaires tend to be inexpensive and easy to administer. When national occupational survey data is available, comparisons can be made between study participants and national averages of job characteristics by job title. Questionnaire limitations include the possibility of self-report bias, difficulties due to low literacy, and problems of transcultural validation (e.g., translation into the participants' native language). We recommend supplementing generic job stressor questionnaires with questions specific to the occupation(s) and target groups being studied. Specific data is particularly useful for intervention research and communicating study findings to participants. When study participants have identical job titles and the same employer, self-report measures averaged across that job title may reduce the likelihood of self-report bias.

Imputation of job characteristics scores does not suffer from the same problems as self reports, and they can be used in studies containing information on an individual's occupation but no details of work characteristics. The limitations of this method include the loss of within-occupation variability in work characteristics, the lack of precision of occupation means for small occupations, and the questionable generality of the occupation scores to subpopulations and other time periods.

External assessment of job characteristics can be time-consuming and expensive to conduct; however, this method is valuable in certain situations (see pages 182–183).

In general, we recommend multimethod strategies—convergent validation using as many of these approaches as possible. A number of important issues remain to be resolved through future research:

1. Assessment methods that integrate self-reported stressors with objective features of the job, such as the OSI, require further development and testing.[10]

2. The constructs of job demands and job control may require expansion to improve prediction of CVD, hypertension, and other health outcomes. Adding a measure of organizational influence to the task-level decision-latitude variable produced a stronger association with hypertension due to job strain in the Cornell study.[64] To what extent is "low job security and limited career opportunities" an important risk factor beyond task-level or even organizational level control, as suggested by the Whitehall study?[14] To what extent is control exercised collectively as important as individually exercised control in reducing job strain and CVD risk?[47] Similarly, is CVD risk associated with various alternative conceptualizations of psychological job demands, such as problem-solving, monitoring or emotional demands, or threat/disaster potential? Valid instruments are needed to measure global systems of work organization, such as lean production, and to apply to economically underdeveloped areas of the world. These factors can have dramatic effects on job characteristics.[62]

3. To what extent are current questionnaires valid for service occupations, women, ethnic minorities, older workers, and conditions of downsizing and new work systems?[43] The JCQ and other job stressor questionnaires need to be further tested in different populations, particularly non-Northern European racial/ethnic groups.

4. Periodic, detailed occupational surveys (such as the Quality of Employment Surveys) in the U.S., similar to those being conducted in Europe, are needed to determine job characteristics' time trends and current occupational averages.

5. Are certain survey or expert observer methods (or job stressor models) more predictive of certain health outcomes (e.g., CVD, work-related musculoskeletal disorders, or psychological strain outcomes) than others?

6. Are there differences in validity of external assessment and self-report assessment for different dimensions of job characteristics?

7. Do psychological constructs such as denial or repressive coping help to explain paradoxical results in stress research? [109] Does contrasting externally assessed measures with self-report measures and studying inconsistencies between the two on the level of the individual help to shed light on the role of repressive coping?

8. Are expert observer methods applied and used in cooperation with management and employees toward the goals of stress reduction and increased skill utilization,[103] or are they used predominantly to increase productivity?

9. How much do qualitative assessment methods (e.g., focus groups, interviews, and ethnographic observation), in conjunction with quantitative methods, improve our understanding of the social context of stress in a particular workplace and help us conduct and evaluate interventions?[73,78] Standardized interviews may better explore the objective components of psychological demands, decision latitude, and social support at work.[105] Qualitative assessment, especially in intervention studies, allows researchers to learn from employees about the context of stress, helps insure dissemination of results, and serves educational purposes for all participants.

10. To what degree can both employees and management be included in the development of assessment methods, and support the collection and interpretation of data?[44] Researchers have to maintain scientific standards in their study, but if studies are to lead to positive change in the workplace, employees and management must be involved. How can the balance between science and practical application be maintained?

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