

# **The Role of Work in Cardiovascular Disease**

**Peter L. Schnall, MD, MPH**

**Dean Baker, MD, MPH**

University of California, Irvine

Center for Occupational and Environmental Health

**Prepared for the DMEC Conference**

**July 21 2003**

**Newport Beach, Ca**

# Presentation Overview

- **What is the problem? Work and the CVD epidemic**
- **Review Concepts of Work-related Stress**
  - Job Strain, Effort-Reward Imbalance, and Threat Avoidant Vigilant Work
- **Review Research Findings Connecting Psychosocial Factors and Heart Disease**
  - Cornell Study
- **Discuss Workplace Interventions and Impacts on Worker Health, Absenteeism, and Disability**

# **The Epidemic of Hypertension and CVD**

# Worldwide CVD Epidemic

**Cardiovascular disease (CVD) is the major cause of morbidity and mortality in industrialized world.**

**Dramatic increases in CVD morbidity and mortality over last 30 years in Eastern European countries.**

**Rising prevalence rates in many developing countries.**

**“It has been projected that cardiovascular disease worldwide will climb from the second most common cause of death...in 1990, to first place, with more than 36 percent of all deaths in 2020” (Braunwald 1997, p.1364).**

# CVD in the United States

**CVD is the cause of 41% of all deaths.**

**An estimated 250,000 - 350,000 people annually die suddenly of heart disease in the United States. \***

**Another 250,000 people lose their lives each year more slowly due to manifest CVD from which they have chronically suffered.**

**\* 1/2 of these (125,000 people) die with no warning**

# Traditional Medical Research Approach

## Focuses on:

- individual traits, especially genetic susceptibility
- risk behaviors (smoking, diet, sedentary lifestyle, etc.)

## The primary strategies to curtail the CVD epidemic are:

- better management of atherogenic risk factors
- use of medical treatments and technological advances
- additional research into the molecular biology of atherogenic and other cardiodegenerative processes

# Limitations of Traditional Approaches

- While biomedical models are highly sophisticated, our understanding of the etiology of CVD and our ability to manage the epidemic are still limited.
- Traditional risk factors represent “proximate” causes of CVD; each of them has a complex set of determinants, many of which are of psychosocial origin.
- The connection between the social environment and CNS on the one hand, and CNS and cardiovascular system via the automatic nervous system on the other, compels one to look beyond the cardiovascular system “in isolation” to understand how CVD develops.

# New Approaches to Understanding CVD Etiology

- Increased recognition of importance of behavioral factors and social experiences.
- Emergence of social epidemiology as a field which examines social factors as more distal causes or modifiers of disease processes.
- Social epidemiologists have demonstrated that lower socioeconomic status is an important risk factor. However, general social conditions still do not fully explain all the variance in CHD.

# Essential Hypertension: the "Silent Killer"

- Approximately ½ of the adult population in industrialized countries has a persistently elevated BP >140/90mmHg by age 60
- Although risk factors such as age, obesity, alcohol intake etc., have been identified, these factors explain only a part of the risk
- The definition of essential hypertension remains:

*PATIENTS WITH ARTERIAL HYPERTENSION  
AND NO DEFINABLE CAUSE*

# Residual Lifetime Risk for Developing Hypertension in Middle-aged Women and Men - Framingham Heart Study

- Residual lifetime risks for developing hypertension and stage 1 high blood pressure or higher (140/90 mm Hg regardless of treatment) were 90% in both 55- and 65-year-old participants.
- Lifetime probability of receiving antihypertensive medication was 60%.
- Risk remained unchanged for women, but it was 60% higher for men in the 1976-1998 period compared with an earlier 1952-1975 period.

# Hypertension: an Example of the Social-Epidemiological Approach

- Essential hypertension is a major risk factor not only for coronary heart disease, but also for left ventricular hypertrophy, stroke, renal disease, and other major pathologic processes.
- Identified risk factors explain only a small part of the risk.
- Social-epidemiological approach suggests that essential hypertension is a disease of industrialized society.

# Hypertension as a Disease of Industrialized Society

- There is a minimal hypertension disease burden among non-market agricultural communities, and other non-industrialized societies.
- Within industrial society, hypertension is patterned by class, race, ethnicity, urbanicity, and gender.
- The “unidentified” causes of essential hypertension most likely include one or more ubiquitous exposures – e.g., diet, lifestyle, work or community.

# The Organization of Work

# Changes in the Organization of Work

**Profound changes have occurred in the way in which work is organized during the past two hundred years.**

- Craftwork has been replaced by the industrial revolution.
- Skilled workers have been replaced by lower -skilled labor in new machine-based production technologies.
- Taylorism reshaped the workplace with it's emphasis on narrow performance and efficiency using the technique of the assembly line, at the expense of broader employee expertise and knowledge of the work process.
- White collar work, through office automation, has been shaped by the principles of the assembly line.

# Current Trends in Working Conditions

- Working men and women are putting in longer work weeks and are increasingly exposed to job conditions that can undermine CV health.
- In Europe, in 1996, 23% of those employed were working >45 hours per week.
- In the U.S., average weekly work hours increased by 3.5 to 47.1 hours from 1977 to 1997.
- Workers in the U.S. have now surpassed Japanese workers in total number of hours worked per year, and work longer hours than in any other industrialized country.

# Lean Production (Tokyo Declaration, 1998)

- Power to control the production process has been increasingly concentrated in the hands of management.
- The recent trend has been towards an acceleration of these changes in the workplace with an intensification of the work process.
- “These dynamics include organization restructuring, mergers, acquisitions and downsizing, the frantic pace of work and life, the erosion of leisure time, and/or the blending of work and home time.”

# Work and Blood Pressure

- Contemporary work environment is where adults now spend the majority of their waking hours.
- Work activities are increasingly characterized as demanding, constraining, and in other ways stressful.
- Blood pressure (BP) is elevated during working hours.
- Performing demanding, constraining, and otherwise mentally stressful activity provokes sharp rises in BP.
- Specific features of work are implicated as important causes of hypertension, as well as CVD.

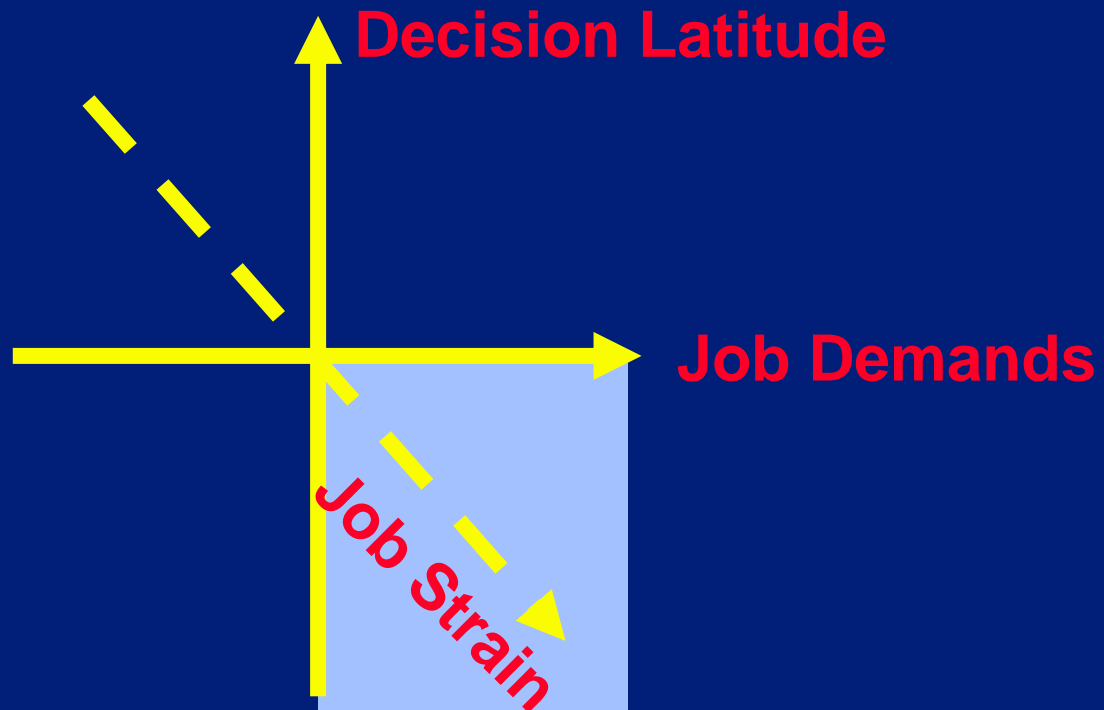
# New Model: Job Strain

- Psychosocial model that relates work organization to physiological outcome
- Relevant to the social changes in the organization of work during past century
- Job Strain - models the relationship between psychosocial stressors at work and BP
- Validated model, well-operationalized

# Job Strain (Karasek)

---

Combination of: HIGH psychological job demands and LOW job decision latitude



# Job Content Questionnaire Items

## Psychological Workload Demands

1. My job requires working very fast
2. My job requires working very hard
3. I am not asked to do an excessive amount of work\*
4. I have enough time to get the job done\*
5. I am free from conflicting demands others make\*

\* item reverse coded

# Job Content Questionnaire (cont'd)

## Job Decision Latitude

1. My job requires that I learn new things
2. My job requires me to be creative
3. My job requires a high level of skill
4. I get to do a variety of things on my job
5. I have a lot to say about what happens on my job
6. My job involves a lot of repetitive work \*
7. My job allows me to make a lot of decisions on my own
8. On my job, I am given a lot of freedom to decide how I do my work
9. I have a lot to say about what happens on my job

\* item reverse coded

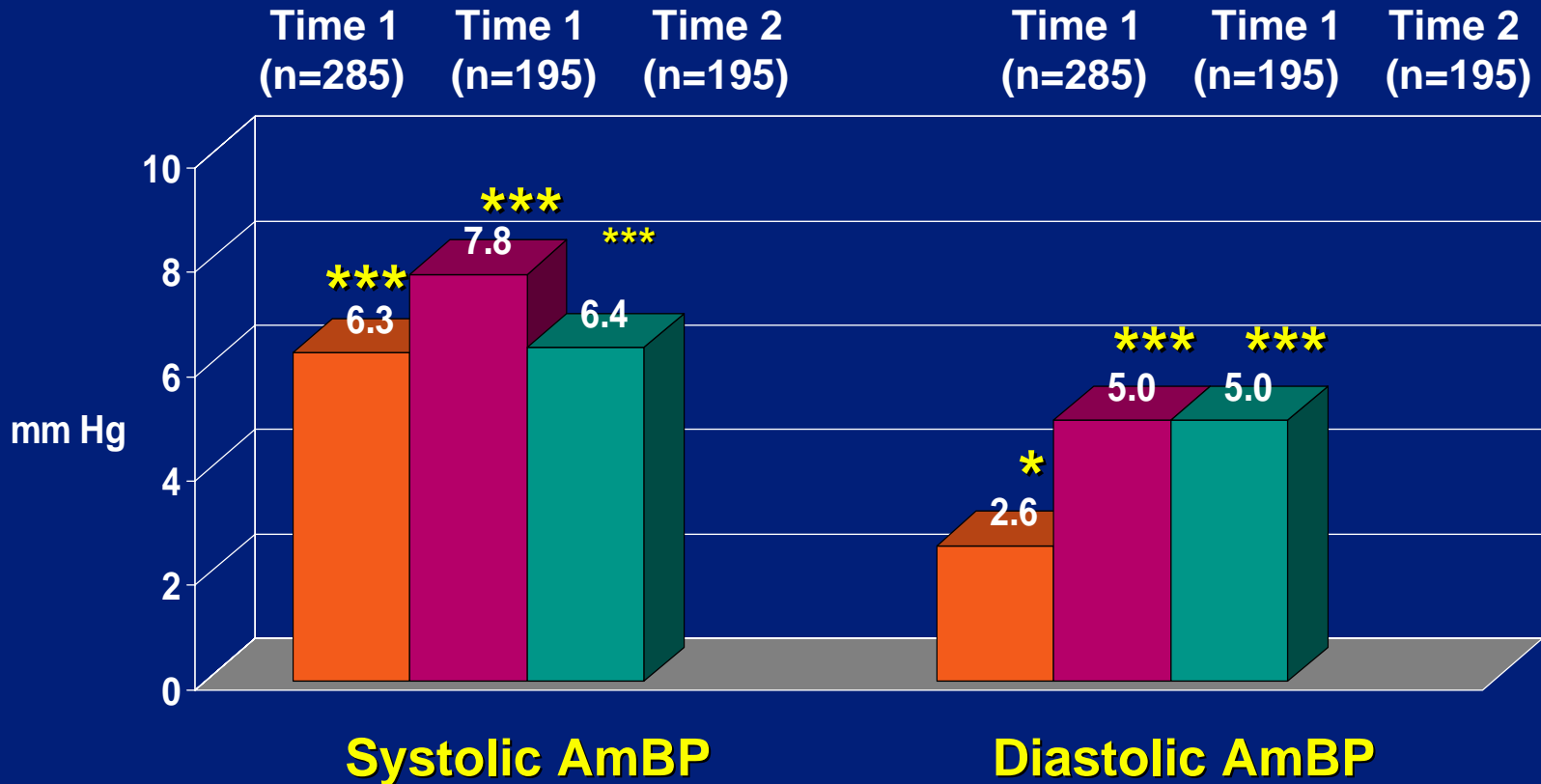
# New York City Work Site Blood Pressure Study 1985-2001

---

- Based at Weill Medical College of Cornell University-New York Presbyterian Hospital
- Began in 1985 as a case-control study
- 283 men initially enrolled at 8 large NYC work sites
- Now prospective study with 10 years of follow-up
- 472 subjects enrolled at 10 sites (38% women)

Source: Schnall et al. *JAMA* 1990;263(14):1929-1935.

# Effect of Job Strain on Work Ambulatory BP in Men (c-s analyses)



controlling for age, education, body mass index, race, smoking, alcohol use, work site

\*\*\*p<.001, \*\*p<.01, \*p<.05

Source: Schnall et al. *Psychosomatic Medicine* 1998;60:697-706.

## **Increased LVMI with Exposure to Job Strain**

**LVMI increased 7.3 gm/m<sup>2</sup> in subjects with job strain compared to those without job strain (p=.03, N=149).**

Schnall et al, JAMA 1990, 1992

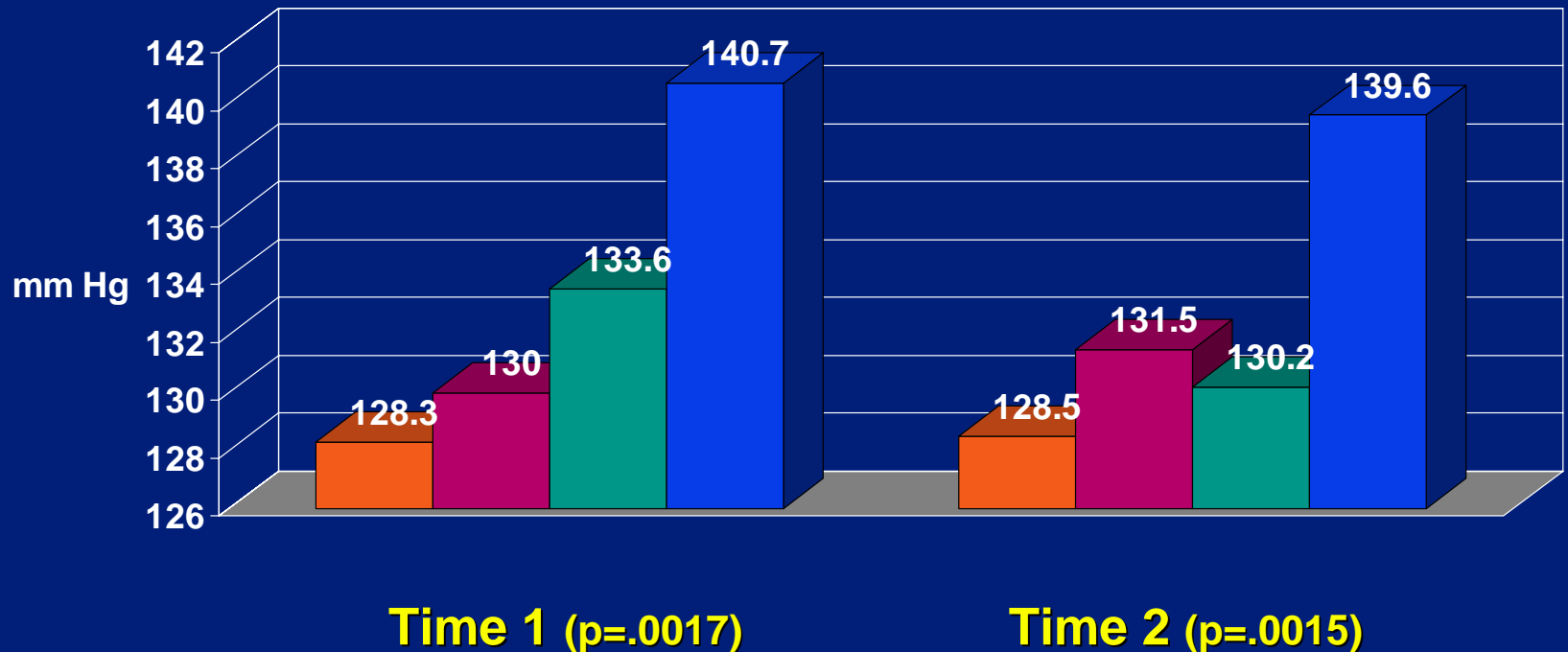
# Job Strain Change Variable



# Job Strain Change and Work Systolic Ambulatory BP

(n=195 men, longitudinal analyses)

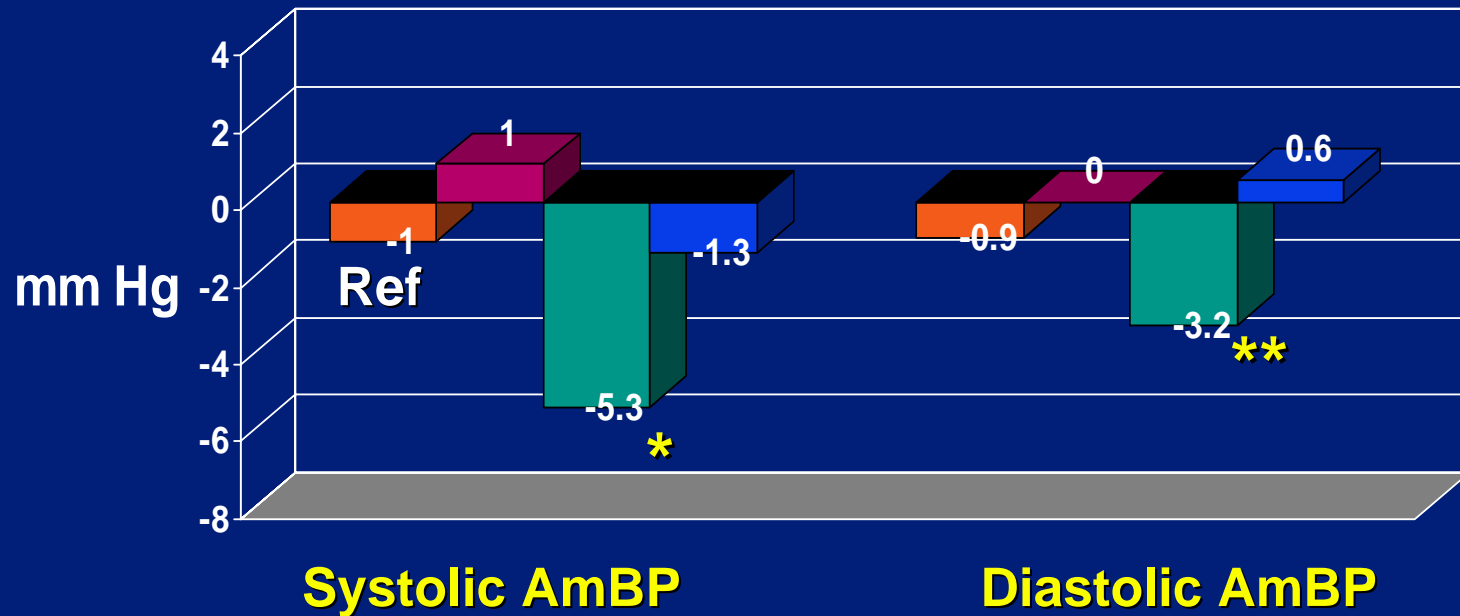
|            |    |     |     |     |    |     |     |     |
|------------|----|-----|-----|-----|----|-----|-----|-----|
| Strain-T1: | no | no  | yes | yes | no | no  | yes | yes |
| Strain-T2: | no | yes | no  | yes | no | yes | no  | yes |



controlling for age, education, body mass index, race, smoking, alcohol use, work site

# Job Strain Change and 3-yr Work AmBP Change (n=195 men, Time 1-2)

|            |    |     |     |     |    |     |     |     |
|------------|----|-----|-----|-----|----|-----|-----|-----|
| Strain-T1: | no | no  | yes | yes | no | no  | yes | yes |
| Strain-T2: | no | yes | no  | yes | no | yes | no  | yes |



controlling for age, race, body mass index, smoking, alcohol use, work site

\*p<.05, \*\*p<.01, (vs Ref group)

Source: Schnall et al. *Psychosomatic Medicine* 1998;60:697-706.

# Hypertension and Psychological Symptoms

- Job strain not associated with anxiety or self-reported feelings of stress in the Cornell Worksite Study
- Fits with idea of hypertension as “silent killer”

# Summary:

## Effects of Work & Job Strain on Systolic AmBP

---

- Work vs. non work + 3-5 mm Hg
- Job Strain vs. no strain + 6-7 mm Hg
- Repeated exposure to job strain compared to one exposure + 5 mm Hg
- Cumulative exposure prior to entering study + 5 mm Hg

Landsbergis, Schnall et al. "Life course exposure to job strain and ambulatory blood pressure among men" *AJE* in press, 2002.

# Job Strain and Risk of MI

Swedish men 45-65 y.o.  
N=1047 cases,  
N=1450 population  
controls

First Hospitalized  
and/or fatal MI

Exposure to high job  
strain quartile

Working men:

RR=2.2 (95% CI=1.2- 4.1)

Manual workers:

RR=10.0 (95% CI=2.6- 38.4)

(Adjusted for hypertension, smoking,  
BMI)

-----  
Hallqvist J, Diderichsen F, et al. Soc Sci Med  
1998.

# Population Attributable Risk % for CVD due to Job Strain (based on C-S results)

---

| <u>Study population</u>  | <u>Years</u> | <u>Study Outcome</u> | <u>% Job Strain Exposure</u> | <u>RR</u> | <u>PAR%</u> |
|--------------------------|--------------|----------------------|------------------------------|-----------|-------------|
| <i>New York City men</i> | 1985-8       | <i>High BP</i>       | 21                           | 2.8       | 27.4        |
| U.S. men - HES           | 1960-2       | MI                   | 21.8                         | 2.48      | 24.4        |
| U.S. men - HANES         | 1971-5       | MI                   | 23.2                         | 3.28      | 34.6        |
| Swedish men              | 1976-86      | CVD                  | 20                           | 1.9       | 15.3        |
| European men<br>& women  | 1996         | CVD                  | 30                           | 1.5-2.0   | 13-23       |
| Swedish men              | 1977-90      | CVD                  | 75 <sup>1</sup>              | 1.72      | 35          |
| Danish men               | 1991         | CVD                  | 6 <sup>2</sup>               | 2         | 6           |
| Danish women             | 1991         | CVD                  | 16 <sup>2</sup>              | 2         | 14          |

<sup>1</sup> exposed to medium and low work control

<sup>2</sup> exposed to monotonous high-paced work (virtually no job strain in Denmark)

## Evidence from Longitudinal Studies of Relationship Between Job Strain and CVD

### Conclusion from Review of 14 Studies:

The evidence, particularly among men...is strong and consistent, that an association exists between exposure to job strain and risk of CV disease.

*Since bias towards the null is present in most of these studies, the magnitude of this association appears to have been substantially underestimated.*

# **Economic Costs of Hypertension and CVD**

**Lost time from work due to illness**

**Lost time from work due to disability as a  
consequence of stroke and heart  
attacks**

**Cost of treating a substantial workforce  
with hypertension and CVD with meds  
and health services**

**Cost of treating the population at  
retirement with illnesses caused in  
large part by work**

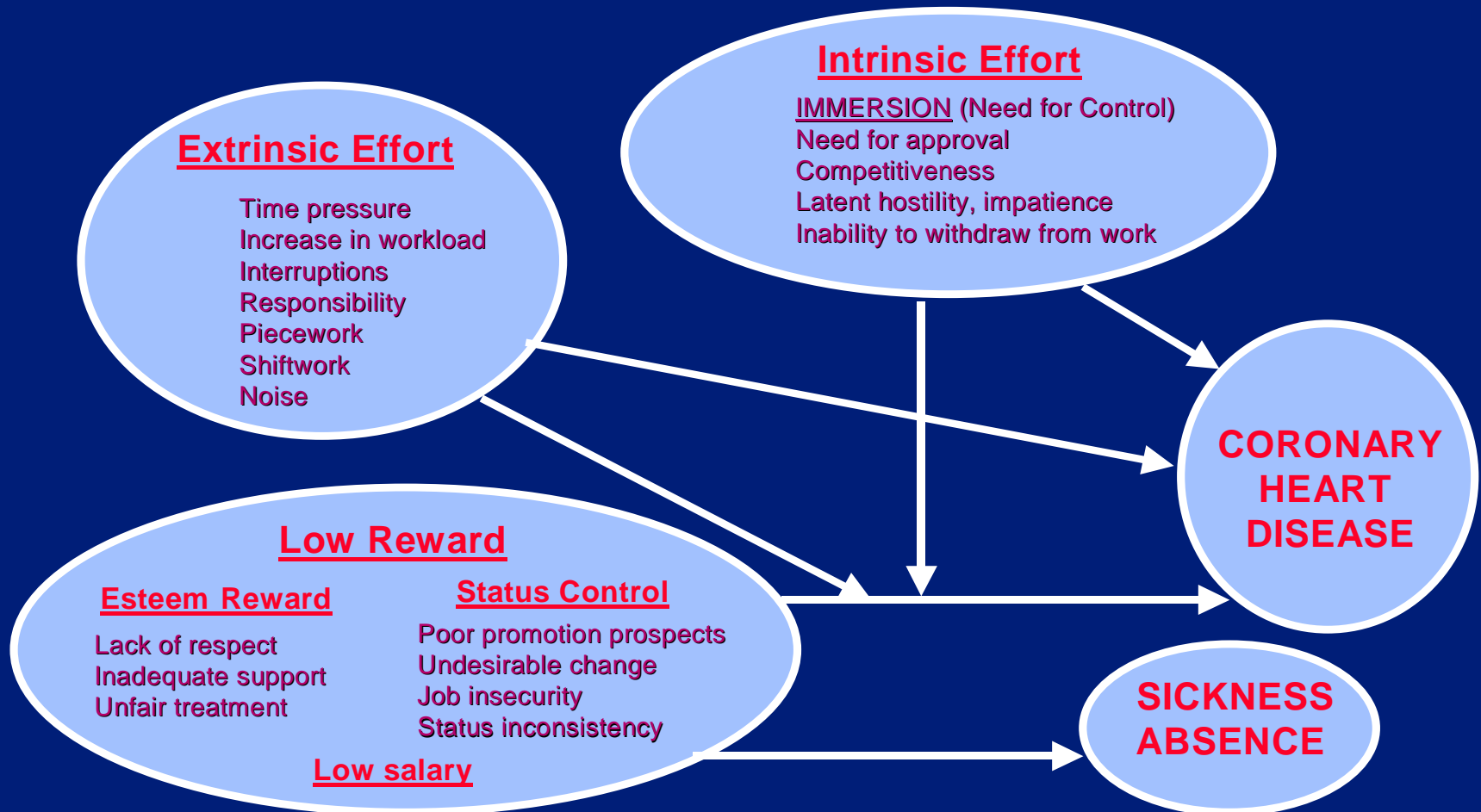
# Workplace Exposures Other than Job Strain

- Effort-Reward Imbalance
- Shift Work
- Long Work Hours
- Threat-avoidant-vigilant work (high risk groups such as bus and truck drivers)
- Physical factors (noise, heat, cold, etc.)
- Chemical factors (lead, carbon monoxide, etc.)



# Effort-reward model of work stress

Johannes Siegrist and Richard Peter



# Effort-Reward Imbalance and MI

**N=2297 middle-aged Eastern Finish men**

**8.1 year follow-up**

**Incident acute Myocardial Infarction**

**Exposure to: High demands, Low Resources, Low Reward**

**RH=2.3 (CI=1.2-4.4)**

*(Adjusted for age, alcohol, smoking physical activity)*

# Shift Work and Risk of Acute MI

Shift Work vs. Day  
work

N=2006 cases

N=2642 population  
controls

OR (95% CI)

*Among those aged 45-55*

1.6 (1.1-2.4): Men

3.0 (1.4-6.5): Women

-----  
Knutsson A, Hallqvist J, et al.  
Occup Environ Med 1999.

*(Adjusted for smoking, job  
strain, educational level)*

# Long Working Hours

- Long working hours and sudden death are most likely related, but not yet well studied.
- *Karoshi* : "Sudden death from ischemic heart disease or cerebrovascular disease due mainly to physiologically demanding work conditions, such as long working hours or shift work."

# Validation of Psychosocial Approach for CVD Risk

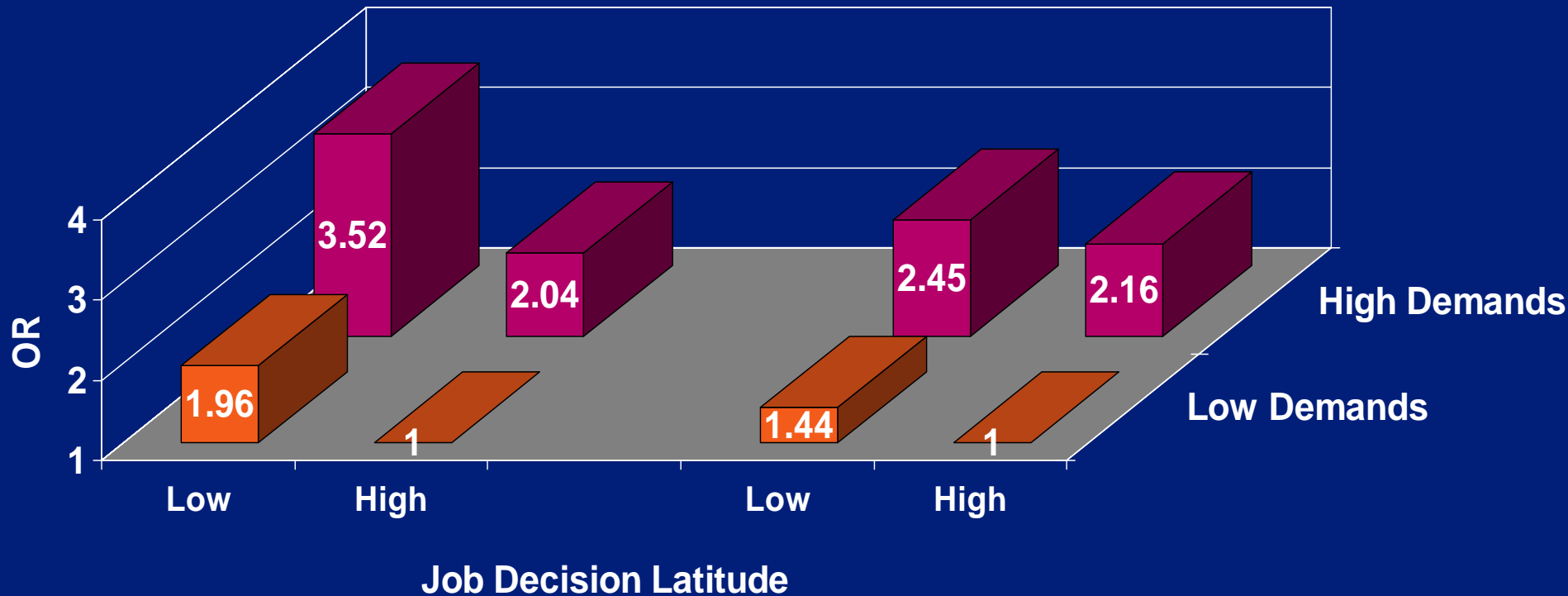
- **Empirical Evidence:** Large body of research confirms the relation of workplace factors to hypertension & CVD.
- **Theoretical Basis:** Theoretical models predict how these factors affect the development of hypertension and CVD
- **Biological Plausibility:** Medical research has demonstrated mediating biological mechanisms by which work stressors are perceived & processed by the CNS, and can lead to cardio-deleterious effects.

# Work Stressors and Mental Health Outcomes

**Job strain has been associated with:**

- Job satisfaction/dissatisfaction
- Anxiety, demoralization, burnout and depression
- With increased sick leave (? absenteeism)
- With disability

# High psychological distress (top 20% of PSI) among 2,889 Quebec white-collar workers, 1992-93

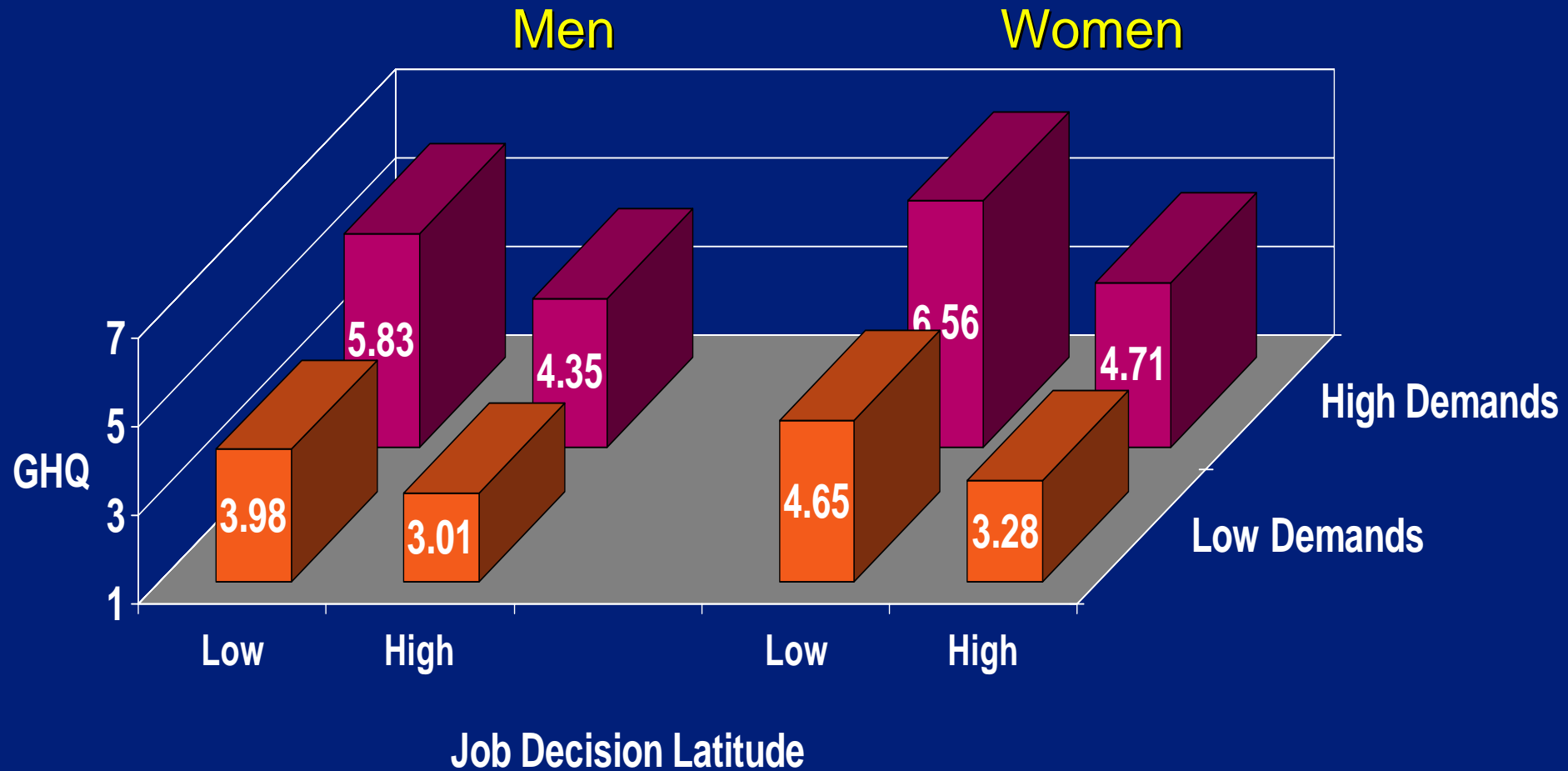


Crude Association

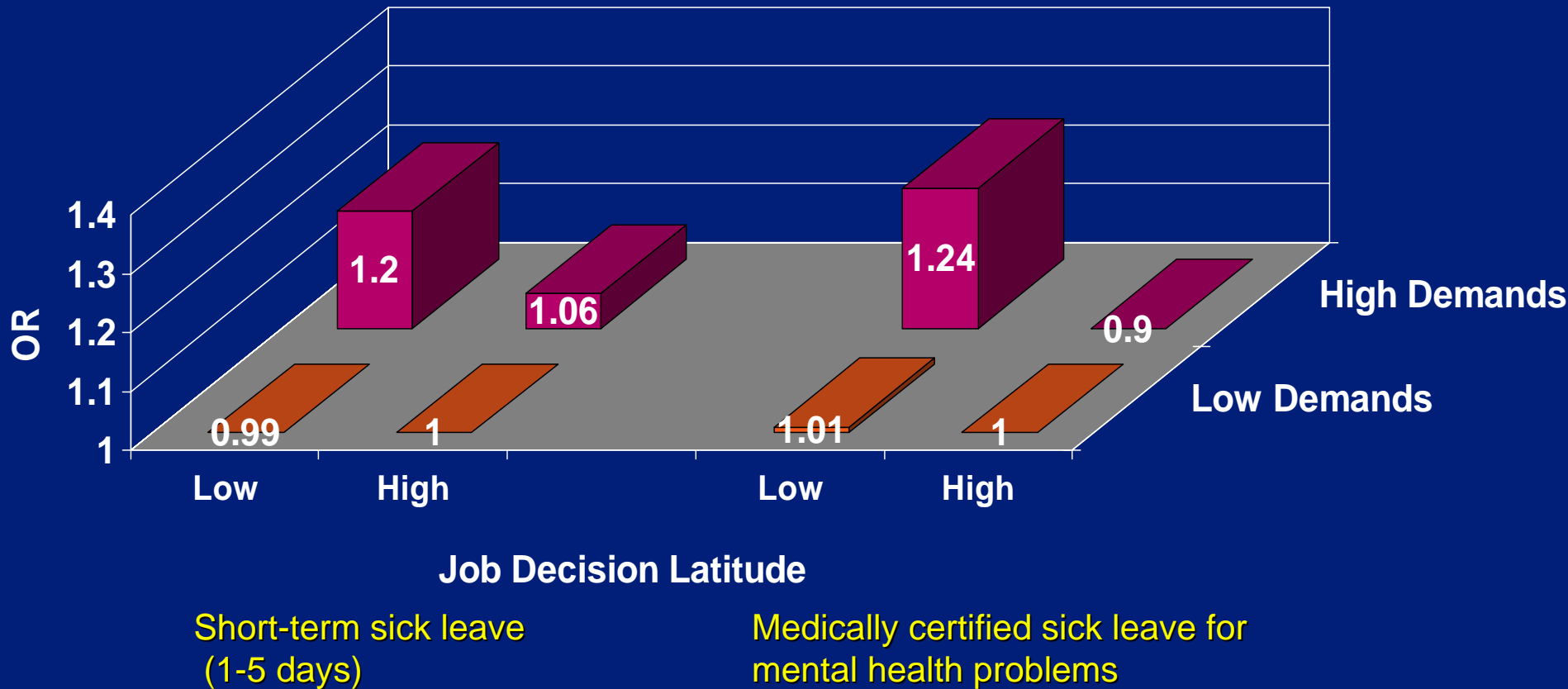
Adjusted for Age, Gender, Employment Status, Occupation, Social Support, Cynicism, Hostility, Domestic Load, Past Year Stressful Life Events

# Psychiatric disorder (30-item GHQ) among 10,314 British civil servants

(Adjusted for age and employment grade)



# Job Strain and Sickness Absence: 20 month follow-up among 1,793 Quebec nurses



# 1999 review article: Van Der Doef & Maes

---

| Total N of<br><u>Outcome</u><br><u>Studies</u> | JDC Model     |               | JDACS Model   |               |    |
|--|---------------|---------------|---------------|---------------|----|
|  | <u>Strain</u> | <u>Buffer</u> | <u>Strain</u> | <u>Buffer</u> |    |
| Psych well-being                               | 28/41         | 15/31         | 9/19          | 2/5           | 43 |
| Job satisfaction                               | 18/30         | 10/23         | 8/14          | 2/6           | 31 |
| Job “burnout”                                  | 3/4           | 0/4           | 1/1           | 0/2           | 4  |
| Job-related<br>Psych well-being                | 7/8           | 1/2           | 1/2           | 1/1           | 8  |

**(ratio of supportive to total studies)**

Van Der Doef, M., & Maes, S. (1999). The job demand-control(-support) model and psychological well-being: a review of 20 years of empirical research. *Work & Stress*, 13(2), 87-114.

**And let us not forget that  
work stressors impact  
family life and vice versa**

# **Clinical Implications – Occupational Cardiology**

What are the clinical implications of the finding that work stressors play a role in the development of essential hypertension and CVD?

# Occult Workplace Hypertension in NYC Work Site BP Study: A public health epidemic?

---

Work diastolic ambulatory blood pressures (mm Hg)

|   | <u>&gt;85</u> | <u>≤85</u> | <u>Total</u> |
|---|---------------|------------|--------------|
| Work site casual >85 DBP<br>Office BP's | 55            | 24         | 79           |
| Work site casual ≤85 DBP<br>Office BP's | 36            | 139        | 175          |

false positives =  $24/79 = 0.30$  (White Coat Hypertension)

false negatives =  $36/175 = 0.21$

# Occult Workplace Hypertension: Association with LVMI

- In NYC study, the “false negatives” had an LVMI  $13\text{g/m}^2$  (CI,  $8\text{-}18\text{ g/m}^2$ ) greater than those with normal waking AmBP and clinic BP's.
- Individuals with “occult hypertension” during waking life had a similar LVMI and prevalence of discrete atherosclerotic plaques compared to 64 patients with both increased clinic and AmBP (true positives). Both groups differed significantly from those with normal AmBP and normal CCBP, after adjusting for covariates.

# Clinical Implications of Misclassification

Type I errors: false positives

*(White Coat Hypertension)*

**Unnecessary treatment**

Type II errors: false negatives

*(Occult Workplace Hypertension)*

**Failure to treat individuals at high risk with elevated worksite AmBP**

# Return to Work

Working people are at increased risk of a repeat MI if they return to work with a job characterized by having “job strain”

Theorell, et al. 1993

# Occupational Cardiology

- Recognize role of work in etiology of hypertension and CVD.
- Establish concept of occupational sentinel health events within realm of cardiology (identification of clusters of work-related hypertension and CVD).
- Incorporate occupational history-taking into standard history
- Encourage broad application of ambulatory monitoring techniques
- Develop and validate protocols for diagnostic work-up of patients with cardionoxious jobs
- Provide guidelines for modification of high-risk workplace, to protect individual patient-workers
- Define and implement a “heart healthy” work environment for all working people

# Why Intervene at the Work Place?

- Primary intervention (i.e. aimed at workplace characteristics themselves) will be the most effective way to prevent risk.
- Interventions located at the worksite are:
  - less expensive than treatment
  - best place to lower established risk factors through behavioral techniques
  - provide cardiovascular disease prevention through work reorganization

# Recommended Strategies and Policy Initiatives for the Worksite

- Surveillance
- Occupational cardiology
- Interventions at the workplace
- Economic incentives for workplaces to lower cardionoxious exposures
- Policies to encourage heart healthy working environments

# **Overview of UC Irvine COEH STEP Program**

**Comprehensive program for the improvement  
of psychosocial well-being and  
musculoskeletal and cardiovascular health**

- 1) Surveillance**
- 2) Training of new health workers**
- 3) Early detection with referral for evaluation and treatment of individuals with early manifestations of disease, and**
- 4) Interventions at the workplace to reduce exposures.**

# Surveillance

---

Participants at an international conference at Tokyo Medical University in 1998 called for:

“*Surveillance* at individual workplaces and *monitoring* at national and regional levels, in order to identify the extent of work-related stress health problems and to provide baselines against which to evaluate efforts at amelioration. They recommend that workplaces assess both workplace stressors and health outcomes known to result from such exposures [e.g., job strain and hypertension] on an annual basis.”

# Implementation of Surveillance for “occult hypertension” at the Worksite

---

- Screen all employees at worksite and obtain point estimates of BP

*Combine with:*

- Assessment of cardiorespiratory worksite stressors (e.g., Job strain)

# Surveillance + Referral

- A comprehensive plan of surveillance with detection of psychosocial exposures and incipient illness will be initiated in cooperation with interested corporations, health care providers, public agencies, and labor unions.
- Working people with identified health problems can be referred to COEH facilities for evaluation and treatment by COEH and medical center staff (including cardiologists).

# Results from 13 “natural experiments” in the transportation industry

## Work directed

- team based work (6 cases)
- social work environment/management style (5 cases)
- work and resting time regulations (4 cases)
- ergonomics (3 cases)
- technical interventions in traffic environment (1 case)

## Person directed

- stress management, relaxation, conflict solving (6 cases)
- healthy behavior (5 cases)
- training for team based work (4 cases)

# Other Swedish interventions to reduce job stress

---

## Automobile assembly-line workers:

Compared traditional to more flexible work organization (small autonomous groups w/ more influence over work pace, content)

### Results:

More flexible: reported more variation, independence & abilities to learn new skills at work

Both: increase in adrenalin during work vs. day off at home

Traditional: during work day, increase in blood pressure, heart rate, adrenalin, fatigue (but not in flexible group)

Flexible: workers able to unwind more rapidly after work (faster drop in adrenalin), particularly for female workers

**Source:** Melin B, Lundberg U, Soderlund J, Granqvist M. Psychophysiological stress reactions of male and female assembly workers: a comparison between two different forms of work organization. *Journal of Organizational Behavior* 1999;20:47-61.

# ECONOMIC LEGISLATION: INCENTIVES FOR LOWERING CARDIONOXIOUS EXPOSURES (AN EXAMPLE FOR THE U.S.)

*We propose a tax be imposed on those industries with jobs that are especially prone to producing circulatory disease. Currently the costs of workplace induced CVD are transferred to society in the form of costs to Medicare and other insurance carriers - what is called a “negative externality”. The proceeds from this tax could be used to defray the costs currently being absorbed by Medicare and the Social Security Administration. This Circulatory Disease Tax Fund could be modeled after the Black Lung Trust Fund that taxes coal companies on a per-ton-of-coal basis and used the money to pay medical and indemnity benefits for persons with pneumoconiosis.*

*The Circulatory Disease Tax Fund will have two beneficial effects.*

1) It will resolve the equity problem. Taxpayers should not have to pay for a problem they were not responsible for.

2) The tax will provide an economic incentive to businesses to decrease the causes of job related circulatory diseases. The tax will encourage businesses to re-assess their workplace arrangements to decrease Job Strain and other job-related causes of circulatory diseases.

# **NEED FOR NATIONAL LEGISLATION TO PROVIDE FOR A HEALTHY WORKING ENVIRONMENT**

## *Swedish Work Environment Act - An Example (Act No. 677, amended in 1991)*

**Working conditions shall be adapted to people's differing physical and psychological circumstances**

**Employees shall be enabled to participate in the arrangement of their own job situations as well as in work changes and development that affect their jobs.**

**Technology, work organization and job content shall be arranged so that the employee is not exposed to physical or mental loads that may cause ill health or accidents.**

**The matters to be considered in this context shall include forms of remuneration and the scheduling of working hours.**

**Rigorously controlled or tied work shall be avoided or restricted.**

**It shall be the aim of work to afford opportunities for variety, social contacts and cooperation as well as continuity between individual tasks.**

**It shall further be the aim for working conditions to afford opportunities for personal and occupational development as well as for self-determination and occupational responsibility.**

**UC Irvine Occupational Medicine  
Program – an Employer and  
Community Resource**

# UC Irvine Occupational Medicine

- Occupational Medicine board-certified physicians and affiliations with specialists
- Occupational health nurses
- Industrial hygienists, toxicologists, epidemiologists, legal expertise
- Occupational health program manager – Joan Keegan, RN, COHN-S
- Employer Services program development and communication – Mindy Inselberg

# UC Irvine Occupational Medicine Physicians and Toxicologists

Dean Baker, MD, MPH

Peter Schnall, MD, MPH

Lester Sacks, MD, PhD

M. Joseph Fedoruk, MD, DABT, CIH

Ulrike Luderer, MD, PhD

Elliott Kornhauser, MD, MBA, MPH

Stephen Bondy, PhD

Robert Phalen, PhD

Michael Kleinman, PhD

# UC Irvine Occupational Health Program Services

- Occupational and Environmental Medicine Specialty Clinic – Irvine on the UCI campus
- Comprehensive Occupational Health Clinic – Orange at the UCI Medical Center
- Primary care services for surveillance and initial injury treatment – Irvine, Westminster, Santa Ana
- Medical and surgical specialists for inpatient and ambulatory care – Orange, UCIMC

# UC Irvine Workplace-based Program Services

- Resource for employers to develop heart healthy workplace programs (STEP)
- Help employers develop knowledge and understanding of local resources in regards to providing healthy workplaces
- Educate employees about heart healthy work and positive health habits
- Provide workplace surveillance programs and clinical referrals

**END**