

**WORKPLACE INTERVENTIONS AND CHANGING PATTERNS OF
CARDIOVASCULAR DISEASE**

Martin Cherniack¹, Jeffrey Dussetschleger¹, Laura Punnett², Manuel Cifuentes², Nick
Warren¹

¹ Ergonomics Technology Center, University of Connecticut Health Center

² Department of Work Environment, University of Massachusetts Lowell

Address of the institution: Ergonomics Technology Center, 263 Farmington Avenue-
MC6210, Farmington, Connecticut 06030-6210, USA.

Address correspondence to: Martin Cherniack, MD, MPH, Director, Ergonomics
Technology Center, 263 Farmington Avenue-MC6210, Farmington, Connecticut 06030-
6210, USA.

Tel: 001 (860) 679-4916

Fax: 001 (860) 679-1978

E-mail: cherniack@nso.uhc.edu

Acknowledgements: This work was presented during the 25th Anniversary of the Collegium Ramazzini, held in Carpi, Italy on October 25-28, 2007.

Short running head: Workplace interventions and changing patterns of cardiovascular disease

Key words: cardiovascular disease, workplace, occupational health, cardio-toxins, “psychosocial environment”, intervention studies

Abbreviations:

BMI	Basal Metabolic Index
CEA	Cost Effectiveness Analysis
COs	Correctional Officers
CPH-NEW	Center for the Promotion of Health in the New England Workplace
CUA	Cost Utility Analysis
CVD	Cardiovascular Disease
DALY	Disability Adjusted Life Years
EAPs	Employee Assistance Professionals
EU	European Union
HITEC	Health Improvement through Employee Training and Control
HRA	Health Risk Assessment
HWE	Healthy Worker Effect
ICD	International Classification of Diseases
IHD	Ischemic Heart Disease
JCQ	Job Content Questionnaire
MDPH	Massachusetts Department of Public Health
MSH	musculoskeletal health
NIOSH	National Institute for Occupational Safety and Health
OECD	Organization for Economic Co-operation and Development
SMR	Standardized Mortality Ratio
UCONN	University of Connecticut
UML	University of Massachusetts Lowell
WHO	World Health Organization
YLL	Years of Life Lost

Outline of section headers

Abstract

Introduction

International differences in cvd mortality and the problem of equity

Cardiovascular disease in exposure-based occupational health studies

Some observations on employment and cardio selectivity

Life course, working life and cardiovascular risk

Measuring the relationship between the work environment and cardiovascular disease

Center for the Promotion of Health in the New England Workplace and chronic
cardiovascular disease interventions

Correctional Officers and Cohort-Targeted Interventions

Nursing aids in long-term care facilities

Dissemination and translation project

Discussion

References

Tables

Figure legends

Figures

Total paper word count: 8,600

ABSTRACT

Introduction

Traditionally, cardiovascular disease (CVD) has been a secondary object of emphasis in workplace-based exposure studies. Reasons include the rarity of “pure” environmental cardio-toxins, assumptions relating to the Healthy Worker Effect (HWE), and wariness towards macro-social risks that appear tied to socioeconomic development. An evolving “psychosocial environment” approach to CVD has focused on contribution of job control and other risk factors to social variations in CVD incidence. Intervention targets include organizational climate, overtime or shiftwork, interference between work and family responsibilities, emotional labor, racial or gender discrimination, and violence at work.

Estimating the Level of Risk

International comparisons of CVD mortality do show that the concentration of risk follows the distribution of national income and its segregations of wealth, education, and income, and show, therefore that no model can fully disentangle risk attribution.

However, in developing industrial economies, the contribution of CVD to disability and death in prime working years exceeds that in the wealthiest countries, and the CVD mortality gradient that works against manual workers is resilient across national boundaries.

Designing Interventions in the Macro-social Context – CPH-NEW

Our current workplace intervention studies in the United States (Center for the Promotion of Health in the New England Workplace – CPH-NEW), adds to the “psychosocial environment” approach with attention to the physical environment and workplace design (“macro-ergonomics”) measuring interventions in physiological and

quantitative terms. Current intervention populations include nursing home workers and correctional officers. Outreach programs are directed to cardiologists and Employee Assistance Program staff.

INTRODUCTION

In industrialized countries, the influence of the workplace, or more generically of the composite elements of working life on cardio-vascular and other chronic diseases, has influenced several major currents in occupational health research. Social and behavioral factors – income, mobility, educational level, work and family inter-relationships – have been particularly emphasized, along with work organization and mismatch between rewards and demands. Two major architects of research in the work and cardiovascular disease field have coined a term, ‘psychosocial environmental’, to capture this relationship between organizational work environment and “needs of well being, productivity and positive self experience”, that accent development of chronic disease. (Siegrist et al. 2004).

The Center for Promotion of Health in the New England Workplace (CPH-NEW) is one of two new American research centers funded by the National Institute for Occupational Safety and Health (NIOSH) in 2006. Its mandate is to develop and evaluate interventions that will integrate the more traditional occupational health emphasis on environmental and physical exposure with worksite based health promotion and disease prevention through social and behavioral approaches (Figure 1). It is based on the premise that the linking of health promotion and workplace health and safety programs will positively affect individual health and the work environment and that those effects can be objectively measured in terms of health status and program costs. While much of the emphasis is on musculoskeletal health (MSH), there is an implicit recognition of the relationship between the integrity of the musculoskeletal and cardiovascular systems (Bernards et al. 2007; Lund et al. 2006). The center’s *Education, Translation,*

Communication, and Dissemination Project is specifically directed to public health and medical practitioners to inform them on the relationship between workplace factors and job stress and cardiovascular disease and stroke (Table 1). Furthermore, one of the cohorts under study, correctional officers and corrections healthcare staff in the United States prison system, have been the object of study because of imputed high stress and elevated quantitative cardiovascular risk factors (Harenstam et al.1988; Philliber 1987). This integration of contextual and life history factors as critical components of workplace disease is not, however, without controversy and presents particular challenges to many occupational health investigators. In general terms, concerns with workplace organization and equity and with the effects of the work environment on premature expression of chronic disease are rather mainstream interests for current occupational health researchers, labor representatives and policy makers. In particular, cardiovascular disease and mortality in early retirement are native concerns of work stress and hazard pay compensation. Nevertheless CVD has been a secondary object of emphasis in most workplace-based exposure cohort studies. There are six evident reasons: 1) CVD is so prevalent in the general population that more distant or widespread causes (e.g., societal discrimination based on race or gender, environmental noise) are more difficult to recognize through epidemiologic study than more immediate risk factors; 2) exposure to chemical cardio-toxins (TNT, Hg) is relatively uncommon and plays a small attributive role in CVD; 3) SMRs for CVD in large occupational cohort studies are presumed to show a cardio-selective ‘healthy worker effect’ (HWE); 4) variegate regional patterns of CVD pathology may dilute any hazard-specific equivalence of toxic workplace exposures; 5) there is limited acceptance of CVD in worker compensation systems, even

for stress-related attribution; and 6) macro-social risk attribution to factors involving national wealth and workplace culture tend to elude specific interventions. These critical concerns inform our discussion of workplace intervention research broadly, and initiatives underway within CPH-NEW, specifically.

INTERNATIONAL DIFFERENCES IN CVD MORTALITY AND THE PROBLEM OF EQUITY

Where “validated” health status and quality of life surveys are applied, they show large differences in disease patterns among regional groupings. This is true for economically and demographically congruent regions, such as is compiled by the World Bank and WHO (Yusuf et al. 2001), and between comparable countries within regions. (Graziano 2005). The complexity of the relationship between proportional mortality and outcomes indicators of CVD, such as Years of Life Lost (YLL) and Disability Adjusted Life Years (DALY), is captured in Figure 2. In developed European countries, here represented by Italy and Sweden, and in the United States, cardiovascular disease accounts for 15-25% of all deaths, which represents an increasing proportion of deaths in the context of an overall declining age-adjusted CVD mortality rate. In low and middle income countries, here represented by Brazil, Indonesia, China, and Turkey, the proportion of mortality due to CVD may crudely resemble more developed countries, but must be weighed in the context of adjusted CVD mortality rates that are 2-3 times higher, thus contradicting the appearance of parity in CVD mortality proportions. The observation that a higher percentage of YLL occurs in more technically advanced countries has a reciprocal meaning: in less developed economies, lower life expectancy and competing causes of early death are the source of this relative non-congruence. As Graziano (Graziano 2007)

has noted, between high and lower income countries, the causes of CVD differ in significant ways, with the latter societies having greater actual and proportional mortality in the <60 year age group. These include factors that are less common in industrialized countries: the residua of heart disease from infection and malnutrition, higher rates of smoking and consumption of dietary fats, and poorer access to specialized treatment. These relationships are perhaps better characterized in Figure 3. In the richer industrial countries, more than 80% of mortality from CVD occurs after the age of 60, while death in prime working years is considerably more prevalent in lower and middle income countries. Accordingly, the years of life spent with a CVD related disability in less wealthy countries is higher than in the more technically developed states. Except for South Africa, where mortality in the <60 year age group is over 50%, the impact of cardiovascular adjusted disability follows general patterns of national wealth.

International comparisons between the broadest categories of disease and the broadest strata of age are necessarily descriptive and, possibly, ecological. The next level of specific comparison includes countries having comparable income levels, where major employment classifications can be assessed between strata. Kunst and the EU Working Group on Socioeconomic Inequalities in Health have documented large variability in inter-class comparisons in ischemic heart disease (IHD) mortality in OECD countries and the United States (Kunst et al. 1998, 1999). When mortality rates from all causes are compared between manual workers and other workers during the 4th and 5th decades of life, the unfavorable differential for manual workers varies by as much as 150% between countries, and in Switzerland and the Mediterranean countries it approaches parity. When the reference groups consist of professional and administrative workers, the differences

are even greater. However, when the comparison is restricted to ischemic heart disease mortality, the adverse ratios for manual workers are uniformly elevated and much of the between country difference is leveled.

This suggests that within approximate levels of income and development, occupational status has a particular resilience in predicting death from cardiovascular disease. Because the concentration of risk also follows the distribution of national income and its segregations of wealth, education, and income, no model can fully disentangle risk attribution. However, these observations add weight to the conclusions of Marmot et al. (2001) that the steepest social gradients in health are observed at two stages of the life course -- early childhood and midlife, and employment status and quality of work exert strongest effects on health during this midlife period.

CARDIOVASCULAR DISEASE IN EXPOSURE-BASED OCCUPATIONAL HEALTH STUDIES

It is something of a tradition in occupational medicine that CVD has generally not been included in the exposure-based diseases. Through the first 6 editions of Hunter's, '*Diseases of Occupation*', from 1955-1978 (Hunter's 1955-1978), there are no annotated reference to CVD as an occupationally related disorder. A number of workplace agents have been studied as possible cardio-toxins, and a summary of major studies is presented in Table 2. Among the most potent toxins, there was a small increase in IHD mortality (ICD-9 410-414) for tetrachlorodibenzo-p-dioxin with risk concentrated in the most exposed cohort (Steenland et al. 1999). Current attributable risk, however, appears to be negligible. Similarly, the studies on 7000 inorganic mercury millers and miners by Boffetta et al. (2001), while showing an elevation in non-ischemic heart disease, also

show quite low SMRs among the pooled national workforces (SMR 0.77) for IHD.

Carbon disulfide exposure in the viscous rayon industry posed a clear historic hazard although there is no longer a measurable effect that appears detectable with various biological markers (Swaen et al. 1994; Drexler et al. 1995). While the risk may remain in industrial environments with less exacting exposure control, even there controls are described as effective (Tan et al. 2004). There is little reason to implicate workplace chemical agents as principal or co-factors in CVD.

SOME OBSERVATIONS ON EMPLOYMENT AND CARDIO SELECTIVITY

It is widely assumed that a pattern of low attributable risk from exposure-specific workplace hazards is amplified in cohort mortality studies where CVD mortality is invariably less elevated than targeted diseases, particularly occupational cancers. In fact, presumably lower mortality rates from cardiac disease and stroke have served as an indicator of the overall health and selectivity of the workforce. The cardio-selective effects of employment should not be overstated, however. In Table 3, nine cohort mortality studies are presented, several of them conducted by fellows of the Collegium Ramazzini. Two derived from dioxin and chloro-phenol exposed populations but can be seen as more general health and disease characterizations of the chemical industry (Kogevinas et al. 1997; Steenland et al. 1986). Table 3 also includes three prominent studies of asbestos-related mortality (Dement et al. 1983; Seidman et al. 1986; Hodgson et al. 1986) and the Canadian workers study on low-level ionizing radiation exposure (Ashmore et al. 1998). The last of these is sufficiently large and equivalent in its gender representation, that it can be viewed as a characterization of two separate cohorts. Turning to the service sector and potentially high stress jobs, the table includes studies of

police workers (Violanti et al. 1998) and firefighters (Baris et al. 2001). In these last two studies, there is no exposure-specific analysis of the work environment, but because of baseline physical fitness selectivity, these cohorts may also be analogous to prison workers, a group that is further discussed below. Perhaps the most striking finding is the general congruence between cardiovascular mortality and all-cause mortality (Figure 4). Because of different ICD applications and inclusiveness, some studies report ischemic heart disease only (ICD-9 410-414) while others include other cardiac diseases (ICD-9 410.0-429.0), hypertension (405.0-409.0), atherosclerotic conditions (ICD-9 440.0-441.0) and stroke (ICD-9 430.0-438.0). The patterns remain much the same, despite the differences in disease classification. Only in the amosite asbestos workers, where the SMR for all cause mortality is 150, is there a notable difference between all cause and cardiovascular mortality, and in this one case the SMR for cardiac disease remains the highest (SMR 120) for any cohort.

Leaving aside issues of ‘psycho-social behavioral risk’, other assessments from industrial countries ascribe a much higher proportion of work-related risk to physical and structural environmental factors, including shiftwork, noise, and vibration exposure, with an additional strong contribution from sedentary work. Olsen and Christiansen (Olsen et al. 1991) concluded that 16% of male and 22% of female CVD was due to these preventable workplace factors. In Finland, Nurminen and Karaljainen (Nurminen et al. 2001), addressed the extrinsic risks of the workplace with similar conclusions, attributing 12% of CVD risk to shiftwork and noise. Several of these factors are included in Table 3, which includes an estimate of overall attribution to CVD mortality. This is presented more graphically in Figure 5. However, factors such as noise and shiftwork (McNamee et

al. 1996; Tuchsen et al. 2006; Knutsson et al. 2004) overlap with organizational and control factors, even if they are more formally hazards of the physical environment. The concerns with small particles and second-hand smoke exposure carry the same concerns in the workplace that they do in the ambient environment (Torén et al. 2007). The contribution from these factors to risk of CVD death in working populations, while not insubstantial in selected cohorts, remains relatively modest.

LIFE COURSE, WORKING LIFE AND CARDIOVASCULAR RISK

Michael Marmot and his colleagues (Marmot et al. 2001) have accumulated perhaps the most concentrated historical record of the effect of social inequalities, particularly in their workplace components, on health and chronic disease, including cardiovascular disease. In their studies of British civil servants, Marmot et al. (1997) used a job content and an effort reward model (Siegrist et al. 1996) to assess coronary heart disease initial event risk. Other independent variables included age, height, other personal factors (smoking, BMI, exercise, cholesterol and hypertension), and social support. For both men and women, social support contributed very little to the risk gradient for initial cardiac event. Work and age were the predominant contributors and dominated the individual risk profile. The implication is that as much as 50% of the differential in risk of ischemic heart disease may be explained by differences in work organization and demand. This parallels the findings of Kunst et al. (1998) on the differential in cardiovascular mortality between manual and non-manual jobs. The study by Kivimaki et al. (2002) of 4570 industrial workers was even more dramatic in its findings: by combining the psychological and physical components of job strain, a 2-fold risk of cardiovascular mortality was identified within the same country and industry. Extreme work-related

events may carry a greater toll. Vahtera et al. (2004) studied the effect of downsizing and noted a 1.5 to 2 fold increase in cardiovascular mortality in the workforce, depending on the extent of job loss. This again highlights the importance of conditions of work in predicting cardiovascular outcomes.

The current “psychosocial environment” approach to CVD has focused on the contribution of job stress risk factors to variations in CVD incidence. More recent work by Chandola et al. (2005) on the metabolic syndrome, a complex of pre-morbid findings linked to cardiovascular disease, has reinforced these associations with workplace risk at an earlier point in the chronic disease cascade. Over 14 years of observation, job stress was associated with a greater risk of developing metabolic syndrome in an exposure-response pattern that remained robust following adjustment for occupational status (a measure of economic level) and for personal health behaviors. This effect was independent of baseline obesity. On the basis of these observations, it is often assumed that a work environment that offers options of experiencing a level of control over work produces favorable effects on health and well-being whereas the opposite is expected in individuals confined to a more restrictive job design.

There are clear associations between stressful working conditions and the occurrence of acute and chronic cardiovascular events (Schnall et al. 2000; Hall et al. 1993; Karasek et al. 1988; Kristensen 1996; Theorell et al. 1996; Westerholm 1998). Perhaps the most consistent body of workplace-based research links workplace stress to hypertension (Din-Dzietham 2004; Adams et al. 1998) and to angina (ischemic coronary disease) (Chandola et al. 2005). Continuous cardiovascular monitoring has shown the existence of “masked hypertension” at work with a return to normal blood pressure in a clinical setting (Belkic

et al. 2001). Acute events such as heart arrhythmia have also been traced with continuous monitoring and related to occupational stress (Jorna et al. 1993). Other identified risk factors are also important sources of work stress although with less direct mechanisms for cardiovascular disease. These include organizational climate (Clarke et al. 2002) overtime or shiftwork, interference between work and family responsibilities (Gold et al. 1992; Lipscomb et al. 2001; Niedhammer et al. 1996; Rosa et al. 1995), emotional labor (Abraham 1999; Brotheridge et al. 2003; Totterdell et al. 2003), racial or gender discrimination (Jackson et al. 1996; Kessler et al. 1999; Krieger et al. 1996-1997; Landrine et al. 1995; Schultz et al. 2000), and violence at work (Lipscomb et al. 1992). There is additional evidence that poor physical and mental working conditions affect the rate of aging and functional capacity both during and after employment, decreasing elder mental and general health (Cifuentes 2002).

The large variety of risk factors also means a multiplicity of intervention targets. The risks of inundation and dilution are deterrents to intervention projects where job control is a principal outcome.

MEASURING THE RELATIONSHIP BETWEEN THE WORK ENVIRONMENT AND CVD

One limitation of the 'psychosocial environment' approach falls under the domain of measurement. Occupational medicine traditionally places a high priority on reproducible and accurate measurement of exposure and, where possible, individual dose.

Measurement of blood pressure, blood sugar and lipids either at the workplace or in the clinic may seem to offer a sturdier platform than survey-derived psycho-social determinants. This introduces the issue of instruments for workplace evaluation of the

psycho-social work environment. Two models have come into general use for assessment of this relationship between individual, psychological and work sociological factors – the job-strain model and the effort-reward imbalance model. Both models belong to a progressive social tradition of empowerment and change. The Job Content Questionnaire (JCQ) of Karasek (1979) is the most commonly used measurement instrument of the demand-control constructs, with a valuing of the effect of skill development, autonomy, and support at work. More abstractly, resolution of the dilemma of physical and organizational demand without reciprocal power in the workplace can be imagined as broadly as a democratic sensibility. As is widely known, the model has multi-factorial contingencies so that the risk of high demand, for example, is counterposed by the ability to actively control work content. The pattern of high demand and low control (job strain) has carried a particular adverse cardiovascular risk (Schnall et al. 2000; Stansfeld et al. 2002).

With the effort–reward imbalance model, Siegrist (1996) assumes a “distributive justice” institutional perspective, where the labor contract is a reciprocal exchange of work and demand (effort) in return for income, job security, social mobility, and esteem. The “effort-reward imbalance” is designed to measure the symmetry or asymmetry of the relationship. In addition to non-equivalent or asymmetric exchange, particularly when rationalized by local labor surplus, there is a more personal domain, the assessed difficulty in coping with work demands, called ‘overcommitment’. While somewhat different in their approaches to strain and reward, the two models are substantially complementary (Stansfeld et al. 2002; Bosma et al. 1998).

Despite their utility and the progressive nature of their traditions and current focus, elimination of work-related health inequalities, skepticism remains due to problems of application, a more frequent use within wealthy countries, and the localized and particular characteristics of individual workplaces. There is, as well, a concern that the overlap with a lifestyles or workplace health promotion approach replaces a direct responsibility of the employer and the government (quantifiable extrinsic exposure) with a more diffusely shared liability, and a liability with very different levels of access to power and instruments of change.

CPH-NEW AND CHRONIC CVD INTERVENTIONS

The Center for the Promotion of Health in the New England Workplace (CPH-NEW) is a collaborative research-to-practice initiative led by investigators from the University of Massachusetts Lowell (UML) and the University of Connecticut (UCONN). The Center's research goal is to evaluate the feasibility, effectiveness, and economic benefits of integrating occupational health and safety with health promotion interventions to improve employee health. There is a strong emphasis on workplace occupational ergonomic interventions and on worker involvement. Outcomes of particular interest include musculoskeletal health, mental health, and cardiovascular health. The general approach is to pay greater attention to the physical environment and workplace design and organization ("macro-ergonomics") and to quantify physiological function that predicts disease and is susceptible to intervention in the short-term, e.g., sarcopenia, exercise reserve, and power generation.

CPH-NEW has three core projects: one which involves reduction of manual patient handling with two types of wellness programs in a chain of more than 200 nursing

homes; a second which compares professional top-down health and promotion and worker safety programs with participatory programs, with programs based both at a private workplace and a prison; and an outreach program aimed at “mainstreaming” the knowledge about workplace risks of heart disease and stroke into the general preventive and clinical health communities. These specific program initiatives are discussed below in light of previously mentioned complexities of addressing cardiovascular risk in the workplace.

CORRECTIONAL OFFICERS AND COHORT-TARGETED INTERVENTIONS

One major CPH-NEW study, HITEC (Table 1), involves interventions in the working conditions and individual disease risk profiles of correctional officers (COs). While there is increasing attention to the health of inmate populations, there is a very modest body of information on the health of COs. Several studies have described exceptionally high stress levels among correctional officer (Keinan et al. 2007; Schaufeli et al. 2000; Goldberg et al. 2006), limited job autonomy (Dollard et al. 1998), and biomarkers consistent with elevated catecholamines (Harenstam et al. 1988). A study of American correctional officers by McCraty et al. (2003) produced a very complex profile. COs reported considerably less smoking and use of alcohol than reference population, and were much less likely to report serious co-morbidities. Compared to reference groups, they were also much less likely to exercise, were considerably more overweight, and were more likely to be hypertensive and hyperlipidemic. They were also estimated to have a considerably greater biological age than their peers.

The high risk profile of CO's is replicated in other areas, specifically a suicide rate which appears to be double that of reference populations (Stack et al. 1997). Studies of COs

show a high profile of adverse psychosocial factors. Cullen et al. (1985) looked at the domains of work stress, job dissatisfaction and life stress, finding that the physical danger of the job transcended all categories, an important role for supervisory support, and an inverse effect of education on job dissatisfaction. In their review of 43 studies from nine countries, Schaufelli and Peeters (2000) made the somewhat contradictory observations that while stress levels, lack of variety and inability to use training and education were highly negative factors, greater decision latitude was actually associated with greater stress.

The apparent risk profile is of some particular interest, because of the high fitness requirements at the point of hire. In the State of Connecticut, for example, both state police officers and correctional officers must meet the 40th percentile of the Cooper Institute standard, a level which should qualify them as fit and in a reduced cardiac disease risk category (Farrell et al. 1998).

The lack of job satisfaction is reflected in the CPH-NEW CO population by retirement decisions. The average age of retirement is young (50.13 years), and there is an overwhelming selection to leave employment at 20 years of service when full vesting has occurred (Figures 6 and 7).

The level of CVD mortality in COs are controversial. While there is a strong institutional belief in elevated CVD risk, there are scant life data. The Canadian Corrections Service reported that male COs had a life expectancy of 77.48 years, 1.10 years less than other public employees (Beavon et al. 1993). While the conclusion was that concerns over CVD risk may be overstated, there are mitigating issues. Most COs in Canada have retired or left the armed services, join in their third decade, and are considerably more fit

than other government workers at baseline. As noted in the CPH-NEW target population, the very early age at retirement usually results in a 2nd or 3rd career and little institutional tracking of long-term health outcomes. A review of deaths occurring during the 3th and 4th decade of life in the state workforce as compared to the department of corrections workforce showed that COs are 1.5 to 3 times more likely to die during employment as other state workers (Figure 8). While the death rates are crude and are not cause specific, they at least suggest a pattern that requires exploration.

NURSING AIDES IN LONG-TERM CARE FACILITIES

This intervention study is taking place within a large chain of nursing home facilities which has implemented a “no-lift” program involving purchase of resident handling devices in combination with training and related protocols. An optional “Wellness” program has been adopted in 30 of these facilities to date and will follow in others in the near future. In addition, the investigators will implement an independently designed, participatory program in selected other facilities, incorporating best practices in worksite health promotion. The key study comparisons examine changes over time in cardiovascular risk factors, e.g., obesity, smoking, and hypertension; mental health; and health self-efficacy among three groups of centers: NLP alone, NLP plus wellness program, and NLP plus participatory health promotion teams.

To date, about 800 questionnaires have been collected in ten nursing homes from clinical nursing staff, primarily certified nursing aides. These are low-wage workers of which over 90% are female and 65% are Afro-American. One-half worked more than 75 hours per two weeks at the nursing home, and 1 in 5 reported working a second paid job. Only 23% were current smokers; about 25% reported medical history of hypertension. More

than half were overweight or obese, and losing weight was the single most desired change in personal health that participants reported.

With regard to the effect of working conditions on health, respondents exercising at least once per week were more likely to report control over their work schedules, and (less strongly) to have a good work/family balance. Smokers were more likely than non-smokers to report higher levels of job strain and to have experienced recent physical assault at work. Excellent versus poor self-rated health was correlated with good supervisor support, good work-family balance, low job strain, and infrequent exposure to work place assaults. About two-thirds reported that not having enough staff was an important factor in how their job or workplace affects their health. These findings all suggest that employee-directed interventions oriented to the organization of work schedules and social relations could facilitate pre-conditions for improved cardiovascular health.

DISSEMINATION AND TRANSLATION PROJECT

Organized public health efforts designed to raise awareness of CVD and spur concrete action to prevent it should include as an essential component an emphasis on workplace stress. Health educators, other public health professionals, and clinical practitioners must be provided the information they need to address workplace stress and CVD. This project involves the development, delivery and evaluation of curricula on workplace stress and CVD which are targeted to several different professional groups. This targeted education and outreach effort is coordinated with, and in part implemented through, an innovative state-wide consortium for primary, secondary, and tertiary prevention of heart disease and stroke that is organized by the Massachusetts Department of Public Health (MDPH). The

investigators are also collaborating with the chronic disease personnel of MDPH to identify areas of public health activity that would benefit from the inclusion of an occupational health and safety perspective.

We have chosen two pilot audiences for our initial outreach activities. Cardiologists were selected because of the strong and well-documented connection between occupational stress and cardiovascular disease, and our expectation that cardiologists' beliefs and practices exert powerful influence on other clinicians in this area of medicine. Employee Assistance Professionals (EAPs) were selected because they are already engaged in workplace issues as an inherent part of their professional role.

The assessment and curriculum development with EAPs seems to coincide with a beginning of a shift in this profession. Several recent articles in EAP-oriented publications raise the issue of the work environment as an important factor in contributing to employee stress. This is presented as a new, cutting edge concept. The one pilot survey with an EAP and informal conversations suggest that the concept of the work environment as a source of stress potentially significant for health is unfamiliar, but that members of this profession are interested in learning more.

A challenge continues to be the application of this type of knowledge to the work of people in the health and helping professions. Once clinicians or practitioners have improved their understanding of the association between work stress and CVD, it will be imperative to explore with them feasible mechanisms for applying this knowledge to their work with patients and clients.

DISCUSSION

While many of the assumptions about the relationship between work and CVD in terms of international equity and exposure vector may be answerable, significant problems remain.

The first is whether it is methodologically possible to sufficiently segregate the processes of accumulated exposure, critical exposure or period effects, and the combination of social mobility and job process change. For example, in the Turin longitudinal study, Cardano et al. (2004) evaluated the impact of job mobility on standardized mortality in the context of comparative rates between manual workers and professional workers. For men more than women, both gradients were strong predictors of early death. A problem that is particularly pertinent to the life cycle or life history approach is the temporal breath of potential risk factors, coupled to the contributions of various other life factors. Explanatory factors can flood any model.

A second problem is more generic for chronic diseases where there are multiple risk factors and a substantial interval between age when interventions are most effective and age of disease expression. The principal gains in quality of life or life-years gained occur late in working life and are offset by a separation from the most effective period for intervention. For example, the most effective workplace related interventions for controlling hypertension and cardiovascular disease should be targeted to the third decade, where the major health effects and accumulation of lost working years occurs two decades later, and this relationship appears to be even more specific in developing industrial economies (Murray et al. 2003). An intervention directed resource shift to the workplace becomes highly problematic, even when employers have an economic stake in

chronic disease burden. At the least, Cost Effectiveness Analysis (CEA) and Cost Utility Analysis (CUA) can be used to identify cost-neutral CVD interventions and those requiring a resource shift to the workplace. This is only half of the problem, since employers have not been the traditional managers of CVD.

A third problem is the sufficiency of the measurement tools and their applicability to focused intervention. The workplace may be too limited in size and lifespan involvement to subsidize a generalized CVD protective program, particularly if it requires changes in work organization and organizational culture, when most members of the workforce may initiate limited health care costs or productivity losses. The reason is complexity due to the multiplicity of intervention targets that include: organizational climate, overtime or shiftwork, interference between work and family responsibilities, emotional labor, racial or gender discrimination, and violence at work. On the other hand, concentration on the highly morbid sub-populations of the extremely obese or the incumbent CVD population may be too narrow to easily justify costly interventions. Figure 9 depicts a range of pathways and interactions germane to the workplace that influence cardiovascular health and cardiovascular disease. The programmatic costs may exceed the value of labor for all but the largest and wealthiest enterprises.

Finally, the international context, the emphases on medical care of hypertension, dietary shifts and nutrition, and infectious disease, may still outweigh interventions that focus on workplace stress models. Intervention strategies need to be selective and specific.

The evolving intervention program for COs within CPH-NEW will incorporate baseline Health Risk Assessment (HRA) and individual physiologic data in both workplace based and health promotion programs. The particular challenge is the structural origin of risk

factors. On the other hand, the principal issues have a more generic, even international content and lend themselves to generalizability.

REFERENCES

- Abraham R. 1999. The impact of emotional dissonance on organizational commitment and intention to turnover. *J Psychol* 133: 441- 455.
- Adams SL, et al. 1998. Ambulatory blood pressure and Holter monitoring of emergency physicians before, during, and after a night shift. *Acad Emerg Med* 5: 871-7.
- Ashmore JP, Krewski D, Zielinski JM, et al. 1998. First Analysis of Mortality and Occupational Radiation Exposure based on the National Dose Registry of Canada. *Am J Epidemiol* 148: 564-74.
- Baris B, Garrity TJ, Telles JL, et al. 2001. Cohort Mortality Study of Philadelphia Firefighters. *Am J Indus Med* 30: 463-476.
- Beavon DJK, Maxim PS. 1993. The life expectancy of correctional service of Canada employees. *Forum (Special Issue)* 5(1).
- Belkic KL, et al. 2001. Hypertension at the workplace - an occult disease? The need for work site surveillance. *Adv Psychosom Med* 22: 116-38.
- Bernaards CM, Proper KI, Hildebrandt VH. 2007. Physical activity, cardiorespiratory fitness, and body mass index in relationship to work productivity and sickness absence in computer workers with preexisting neck and upper limb symptoms. *Occup Environ Med* 49: 633-40.
- Bjor B, Burstrom L, Nilsson T, Reuterwall C. 2006. Vibration exposure and myocardial infarction incidence: the VHEEP case-control study. *Occup Med* 56: 338 - 344.
- Boffetta P, Sällsten G, Garcia-Gómez M, et al. 2001. Mortality from cardiovascular diseases and exposure to inorganic mercury. *Occup Environ Med* 58: 461-466.

- Bosma H, Peter R, Siegrist J, et al. 1998. Two alternative job stress models and the risk of coronary heart disease. *Am J Public Health* 88: 68–74.
- Brotheridge CM, Lee RT. 2003. Development and Validation of the Emotional Labour Scale. *Journal of Occupational and Organizational Psychology* 76: 365-79.
- Cardano M, Costa G, Demaria M. 2004. Social mobility and health in the Turin longitudinal study. *Soc Sci Med* 58:1563–74.
- Chandola T, Siegrist J, Marmot M. 2005. Do changes in effort-reward imbalance at work contribute to an explanation of the social gradient in angina? *Occup Environ Med* 62: 223-30.
- Cifuentes M. 2002. Salud ocupacional y Adulto Mayor. en Bases conceptuales. Clínica y terapéutica integral Psicogeriatría. Edits. Pilar Quiroga, Gustavo Rohde. Sociedad Chilena de Psiquiatría, Neurología y Neurocirugía. Santiago. Chile. 2002
- Clarke S P, Rockett JL, Sloane D M, et al. 2002. Organizational climate, staffing, and safety equipment as predictors of needlestick injuries and near-misses in hospital nurses. *Am J Infect Control* 2002; 30: 207-16.
- Cragle DL, Hollis DR, Qualters JR, et al. 1984. A mortality study of men exposed to elemental mercury. *J Occup Med* 26:817-821.
- Cullen FT, Link BG, Wolfe NT, et al. 1985. The social dimensions of correctional officer stress. *Justice Quarterly* 2: 505 – 33.
- Dement JM, Harris RL, Symons JM, et al. 1983. Exposures and Mortality Among Chrysotile Asbestos Workers. Part II. Mortality. *Am J Indus Med* 4: 421-453.

- Din-Dzietham R, et al. 2004. Perceived stress following race-based discriminations at work is associated with hypertension in African-Americans. The metro Atlanta heart disease study, 1999-2001. *Social Science & Medicine* 58: 499-61.
- Dollard MF, Winefield A. 1998. A test of the demand-control/support model of work stress in correctional officers. *J Occup Health Psychol* 3: 243-264.
- Drexler H, Ulm K, Hubmann M, et al. 1995. Carbon disulphide. III. Risk factors for coronary heart diseases in workers in the viscose industry. *Int Arch Occup Environ Health* 67: 243-52.
- Farrell SW, Kampert JB, Kohl HW, et al. 1998. Influences of cardiorespiratory fitness levels and other predictors on cardiovascular disease mortality in men. *Med Sci Sports Exerc* 30: 899-905.
- Gold DR, Rogacz S, Bock N, et al. 1992. A. Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. *Am J Public Health* 82: 1011-14.
- Goldberg P, David S, Landre MF, et al. 1996. Work conditions and mental health among prison staff in France. *Scand J Work Environ Health* 22: 45-54.
- Graziano TA. 2005. Cardiovascular disease in the developing world and its cost-effective management. *Circulation* 112: 3547-53.
- Graziano TA. 2007. Reducing the growing burden of cardiovascular disease in the developing world. *Health Affairs* 26: 13-24.
- Hall EM, Johnson JV, Tsung-Shang T. 1993. Women, occupation, and risk of cardiovascular morbidity and mortality. *Occupational Medicine: State of the Art Reviews* 8: 709-20.

- Harenstam AB, Theorell TPG. 1988. Work conditions and urinary excretion of catecholamines – A study of prison staff in Sweden. *Scand J Work Environ Health* 14:257-264.
- Hodgson JO, Jones RD. 1986. Mortality of asbestos workers in England and Wales 1971-81. *Brit J Indus Med* 43: 158-64.
- Hunter's Diseases of Occupational. Edward Arnold, London. Edition 1 1955; Edition 6 1978.
- Jackson J S, Brown TN, Williams D R, Torres M, Sellers SL, Brown K. 1996. Racism and the physical and mental health status of African Americans: A thirteen year national panel study. *Health, Ethnicity, and Disease* 6: 132-147.
- Jorna PG. 1993. Heart rate and workload variations in actual and simulated flight. *Ergonomics* 36: 1043-54.
- Karasek RA, et al. 1988. Job characteristics in relation to the prevalence of myocardial infarction in the US Health Examination Survey (HES) and the Health and Nutrition Examination Survey (HANES). *Am J Public Health* 78: 910-8.
- Karasek RA. 1979. Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. *Adm Sci Q* 24: 285-308.
- Keinan G, Malach-Pines A. 2007. Stress and burnout among prison personnel: sources, outcomes, and intervention strategies. *Crim Justice Behav* 34: 380-398.
- Kessler RC, Mickelson KD, Williams DR. 1999. The Prevalence, Distribution, and Mental Health Correlates of Perceived Discrimination in the United States. *J Health Soc Behav* 40: 208-230.

- Kivimäki M, Leino-Arjas P, Luukkonen R, et al. 2002. Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees. *BMJ* 325; 857- 62.
- Knutsson A, Hammar N, Karlsson B. 2004. Shift Workers' Mortality Scrutinized. *Chronobiology Intern* 21:1049-53.
- Kogevinas M et al. 1997. Cancer mortality in workers exposed to phenoxy herbicides, chlorophenols, and dioxins: an expanded and updated international cohort study. *Am J Epid* 145: 1061-75.
- Krieger N, Sidney S. 1996. Racial discrimination and blood pressure: The Cardiac Study of young Black and White adults. *Am J Public Health* 10:1370-1378.
- Krieger N, Williams DR, Moss NE. 1997. Measuring Social Class in US Public Health Research: Concepts, Methodologies, and Guidelines. *Ann Rev Public Health* 18:141-78.
- Kristensen T. 1996. Job stress and cardiovascular disease: a theoretical critical review. *J Occup Health Psychol* 1: 246-60.
- Kunst AE, Groenhouf F, Andersen O, Borgan JK, Costa G, Desplanques G, et al. 1999. Occupational class and ischemic heart disease mortality in the United States and 11 European countries. *Am J Public Health* 89:47-53.
- Kunst AE, Groenhouf F, Mackenbach JP. 1998. Mortality by occupational class among men 30-64 years in 11 European countries. EU Working Group on Socioeconomic Inequalities in Health. *Soc Sci Med* 46:1459-76.

- Landrine H, Klonoff EA, Gibbs J, et al. 1995. Physical and psychiatric correlates of gender discrimination. an application of the schedule of sexist events. *Psychology of women quarterly* 19: 473-92.
- Levine RJ, Andjelkovich DA, Kersteter SL, Arp EW Jr, Balogh SA, Blunden PB, et al. 1986. Heart disease in workers exposed to dinitrotoluene. *J Occup Med* 28:811-816.
- Lipscomb J A, Trinkoff AM, Geiger-Brown J, et al. 2002. Work-schedule characteristics and reported musculoskeletal disorders of registered nurses. *Scand J Work Environ Health* 28: 394-401.
- Lipscomb JA, Love CC. 1992. Violence toward health care workers. an emerging occupational hazard. *AAOHN J* 40.
- Lund T, Labriola M, Christensen KB, et al. 2006. Physical work environment risk factors for long term sickness absence: prospective findings among a cohort of 5357 employees in Denmark. *BMJ* 332: 449-52.
- MacMahon B, Monson R. 1988. Mortality in the US rayon industry, *J Oncol Manag* 30:698-705.
- Marmot MG, Bosma H, Hemingway H. 1997. Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *Lancet* 350: 235–39.
- Marmot, M., Shipley, M., Brunner, E., et al. 2001. Relative contribution of early life and adult socioeconomic factors to adult morbidity in the Whitehall II study. *J Epidemiol Community Health* 55: 301–307.
- McCraty R, Atkinson M, Lipsenthal L, et al. 2003. Impact of the power to change performance program on stress and health risks in correctional officers. HeartMath Research Center, Institute of HeartMath, Report No. 03-014. Boulder Creek, CA.

- McNamee R, Binks K, Jones S, Faulkner D, Slovak A, Cherry NM. 1996. Shiftwork and mortality from ischaemic heart disease. *Occup Environ Med* 53: 367-73.
- Murray C, Lauer J, Hutubessy R, et al. 2003. Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular-disease risk. *Lancet* 361: 717-25.
- Niedhammer I, Lert F, Marne MJ. 1996. Prevalence of Overweight and Weight Gain in Relation to Night Work in a Nurses' Cohort. *Int J Obes Relat Metab Disord* 20: 625-33.
- Nurminen M, Karjalainen A. 2001. Epidemiologic estimate of the proportion of fatalities related to occupational factors in Finland. *Scand J Work Environ Health* 27: 161-213.
- Olsen O, Kristensen TS. 1991. Impact of work environment on cardiovascular diseases in Denmark. *J Epidemiol Community Health* 45: 4-9.
- Philliber S. 1987. Thy brother's keeper: A review of the literature on correctional officers. *Justice Quarterly* 4:1: 9 - 37.
- Rosa RR. 1995. Extended Workshifts and Excessive Fatigue. *J Sleep Res* 4 (suppl 2): 51-6.
- Schaufeli WB, Peeters MC. 2000. Job stress and burnout among correctional officers: A literature review. *Int J Stress Manag* 7: 19-48.
- Schnall PL, Belkic K, Landsbergis P, Baker, D. 2000. The workplace and cardiovascular disease. *Occupational Medicine: State of the Art Reviews* 15: 1-334.
- Schultz A, Isreal B, Williams D, et al. 2000. Social inequalities, stressors and self reported health status among African American and white women in the Detroit metropolitan area. *Soc Sci Med* 51: 1639-53.

- Seidman H, Selikoff IJ, Gelb SK. 1986. Mortality experience of amosite asbestos factory workers: dose-response relationships 5-40 years after onset of short-term work exposure. *Am J Indus Med* 10: 479-514.
- Siegrist J. 1996. Adverse health effects of high effort — low reward conditions at work. *J Occup Health Psychol* 1: 27–43.
- Siegrist JM, Marmot M. 2004. Inequalities and the psychosocial environment - two scientific challenges. *Social Science & Medicine* 58: 1463-1473.
- Sorahan T, Hamilton L, Tongeren MV, Gardiner K, Harrington JM. 2001. A Cohort Mortality Study of U.K. Carbon Black Workers, 1951-1996. *Am J Indus Med* 39:159-170.
- Stack SJ, Tsoudis O. 1997. Suicide risk among correctional officers: A logistic regression analysis. *Arch Suicide Res* 3: 183–6.
- Stansfeld S, Marmot M. 2002. Stress and the heart. Psychosocial pathways to coronary heart disease. London: BMJ Books.
- Stayner LT, Dannenberg AL, Thun M, Reeve G, Bloom TF, Boeniger M, et al. 1992. Cardiovascular mortality among munitions workers exposed to nitroglycerin and dinitrotoluene. *Scand J Work Environ Health*. 18:34-43.
- Steenland K, Carrano A, Ratcliffe J, et al. 1986. A cytogenetic study of papaya workers exposed to ethylene dibromide. *170*: 151-60.
- Steenland K, Piacitelli L, Deddens J, et al. 1999. Cancer, heart disease and diabetes in workers exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin. *J Natl Cancer Inst* 91: 779-786.

- Swaen GM, Braun C, Slangen JJ. 1994. Mortality of Dutch workers exposed to carbon disulfide. *Int Arch Occup Environ Health* 66: 103-110.
- Tan X, Chen G, Peng X, et al. 2004. Cross-sectional study of cardiovascular effects of carbon disulfide among Chinese workers of a viscose factory. *Int J Hyg Environ Health* 207: 217-25.
- Theorell T, Karasek RA. 1996. Current issues relating to psychosocial job strain and cardiovascular disease research. *J Occup Health Psychol* 1: 9-26.
- Tolonen M, Hernberg S, Nurminen M, Tiitola K. 1975. A follow-up study of coronary heart disease in viscose rayon workers exposed to carbon disulphide. *Br J Indus Med* 32:1-10.
- Tolonen M, Nurminen M, Hernberg S. 1979. Ten-year coronary mortality of workers exposed to carbon disulfide. *Scand J Work Environ Health* 5:109-114.
- Torén K, Bergdahl IA, Nilsson T, Järholm T. 2007. Occupational exposure to particulate air pollution and mortality due to ischaemic heart disease and cerebrovascular disease. *Occup Environ Med* 64:515-519.
- Torén K, Bergdahl IA, Nilsson T, et al. 2007. Occupational exposure to particulate air pollution and mortality due to ischaemic heart disease and cerebrovascular disease. *Occup Environ Med* 64: 515-519.
- Totterdell P, Holman D. 2003. Emotion regulation in customer service roles: testing a model of emotional labor. *Journal of Occupational Health Psychology* 8: 55-73.
- Tuchsen F, Hannez H, Burr H. 2006. A 12 year prospective study of circulatory disease among Danish shiftworkers. *Occup Environ Med* 63: 451-55.

- Vahtera J, Kivimäki M, Pentti J, et al. 2004. Organisational downsizing, sickness absence, and mortality: 10-town prospective cohort study. *BMJ* 328: 555-60.
- Van Kempen EEMM, Kruize H, Boshuizen HC, Ameling CB, Staatsen BAM, De Hollander AEM. 2002. The Association between Noise Exposure and Blood Pressure and Ischemic Heart Disease: A Meta-Analysis. *Environ Health Perspect* 110: 307-317.
- Violanti JM, Vena JE, Petralia S. 1998. Mortality of a Police Cohort: 1950–1990. *Am J Ind Med* 33: 366–373.
- Westerholm P. 1998. Gender, Work and Cardiovascular Disease. In: *The Heart - A Weak Spot, in Women's Health at Work*. (Kilbom A, Messing K, Thorbjörnsson CB, eds). Stockholm: Arbetslivsinstitutet: 165-81.
- Yusuf S, Reddy S, Ounpuu S, et al. 2001. Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. *Circulation* 104: 2746-53.

Table 1. Core Projects of CPH-NEW

<p>Project A <i>Promoting Physical and Mental Health of Caregivers through Transdisciplinary Intervention</i></p>	<p>Interventions:</p> <ol style="list-style-type: none"> 1. ergonomics intervention only 2. ergonomics intervention plus health promotion 3. a participatory health promotion regimen integrated with the ergonomics intervention involving more than 200 nursing homes
<p>Project B <i>Health Improvement Through Training and Employee Control (HITEC)</i></p>	<p>Comparisons at paired sites of traditional workplace health promotion intervention program with an experimental program featuring program development through employee participation.</p>
<p>Project C <i>The Education, Translation, Communication and Dissemination Project</i></p>	<p>Outreach program to traditional and non-traditional practitioners to extend 1) the definition and efficacy of health promotion-occupational health and safety integration, and 2) the relationship between work-related stress and the development of heart disease and stroke.</p>

Table 2. Agent Specific Occupational Exposures and CVD Morality

Agent	Studies	Result	Attributable CVD Mortality Workforce Risk
2,3,7,8-tetrachlorodibenzo-p-dioxin	Steenland et al.1999	~10% elevated IHD mortality	<1% No significant current risk
Inorganic Mercury	Boffetta et al. 2001 Cragle et al. 1984	No IHD ↑ mortality No IHD ↑ mortality	<1% No evidence of risk
Carbon Disulfide	Tolonen et al. 1975 Tolonen et al. 1979 Macmahon and Monson, 1988 Drexler et al. 1995 Swaen et al. 1994 Tan et al. 2004	2x ↑CVD mortality f/u ↑ risk of fatal MI (4-8x) ~40% ↑CVD mortality No CV risk at current levels 15% ↑CVD mortality(1947-80) No risk in current workforce	<1% Historic risk to older workers; no measurable risk in current workplace
Nitrate Esters	Stayner et al. 1992 Levine et al. 1986	No ↑CVD mortality 31% ↑CVD mortality 1940-50s	<1% No current risk
Noise and Vibration	Van Kempen et al. 2002 Bohr et al. 2006 Nurminen and Karjailanen 2001	20% ↑CVD mortality per 5 db 1.4-2.0 OR↑MI incidence 20% ↑IHD risk (including shiftwork)	5% risk
Second hand smoke Small particles	Toren et al. 2007	10% ↑IHD mortality	2.5% risk
Shiftwork	McNamee et al. 1996 Tuchsen et al .2006 Knutson et al. 2004	~10%↓ mortality risk 33%↑CVD risk 5%↑all cause mortality	↑5% mortality risk

Table 3. Cardiovascular Mortality in Selected Cohort Studies

Study	Exposure	Population	Total Deaths	All Cause Mortality - SMR	Cardiovascular Mortality – SMR ICD-9: 390-458
Kogevinas et al. 1997	Phenoxy herbicides/ chlorophenols	9 countries 36 cohorts 21,863 subjects	4,026 ♂ 133 ♀	0.97 [0.94-1.00] ♂ 0.98 [0.82-1.17] ♀	0.91 [0.87-0.95] ♂ 1.00 [0.73-1.32] ♀
Sorahan et al. 2001	Carbon Black	1,147♂	372♂	1.13 [1.02-1.25] ♂	1.00 [0.85-1.17] ♂
Baris et al. 2001	Firefighting	7,789♂	2,220♂	0.96 [0.92-0.99] ♂	1.01 [0.96-1.07] ♂
Dement et al. 1983	Asbestos textiles	1,261♂	308♂	1.50 ♂	1.25 ♂*
Hodgson and Jones 1986	Asbestos	31,150♂	1,128♂	0.87 ♂	0.83 ♂
Steenland et al. 1999	Dioxin/chem workers	5,132 ♂	1,444♂	1.03 (0.97–1.08) ♂	1.09 (1.00–1.20) ♂+
Seidman et al. 1986	Asbestos	820♂	593♂	1.67 ♂	1.20♂#
Ashmore et al. 1998	Ionizing radiation	206,620 105,456♂ 101,164♀	4,210♂ 2,016♀	0.59 [0.57-0.60] ♂ 0.61 [0.59-0.65] ♀	0.61 [0.59-0.64] ♂ 0.50 [0.45-0.55] ♀
Violanti et al. 1998	Police work	2,693♂	1,035♂	1.10 [1.04–1.17]♂	1.00 [0.92–1.10]♂
*ICDA- 400-468; +ICD-9 – 410-414 (IHD); # ICD unspecified					

FIGURE LEGENDS

Figure 1. Paradigm for CPH-NEW

Figure 2. International comparisons of Cardiovascular mortality. Source: http://www.who.int/cardiovascular_diseases_resources/atlas/en/ [date accessed]

Figure 3. Healthy Worker Effect and Cardiovascular Mortality. Source: Annex Table 1, World Health Report 2004. www.who.int/whr [date accessed]

Figure 4. Comparison of SMR for CVD and All Cause Mortality in Selected Cohort Studies

Figure 5. CVD mortality and known causes

Figure 6. Retirement Age of Department of Correctional Officers

Figure 7. Average Tenure at Retirement – Correctional Officers

Figure 8. Mortality of Public Sector Workers

Figure 9. The Patterns of Interactive Risks

Figure 1.

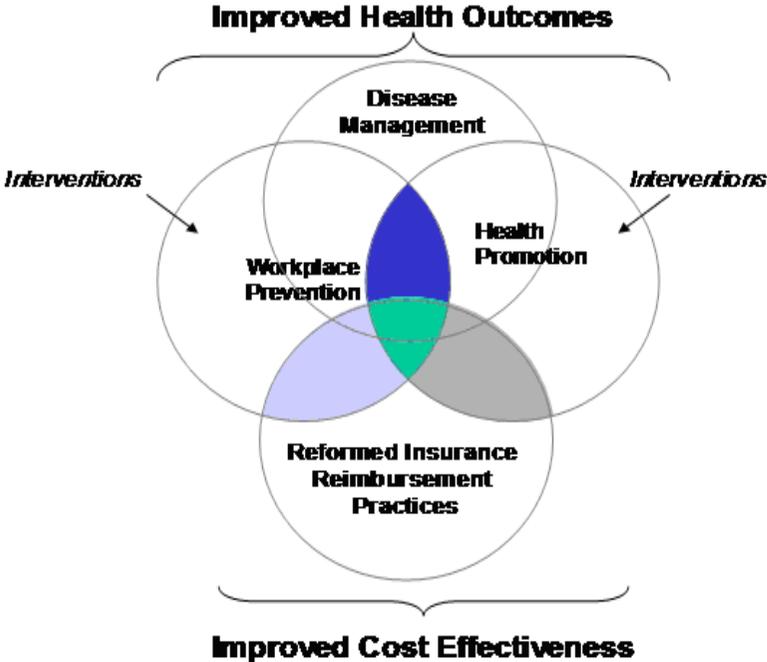


Figure 2.

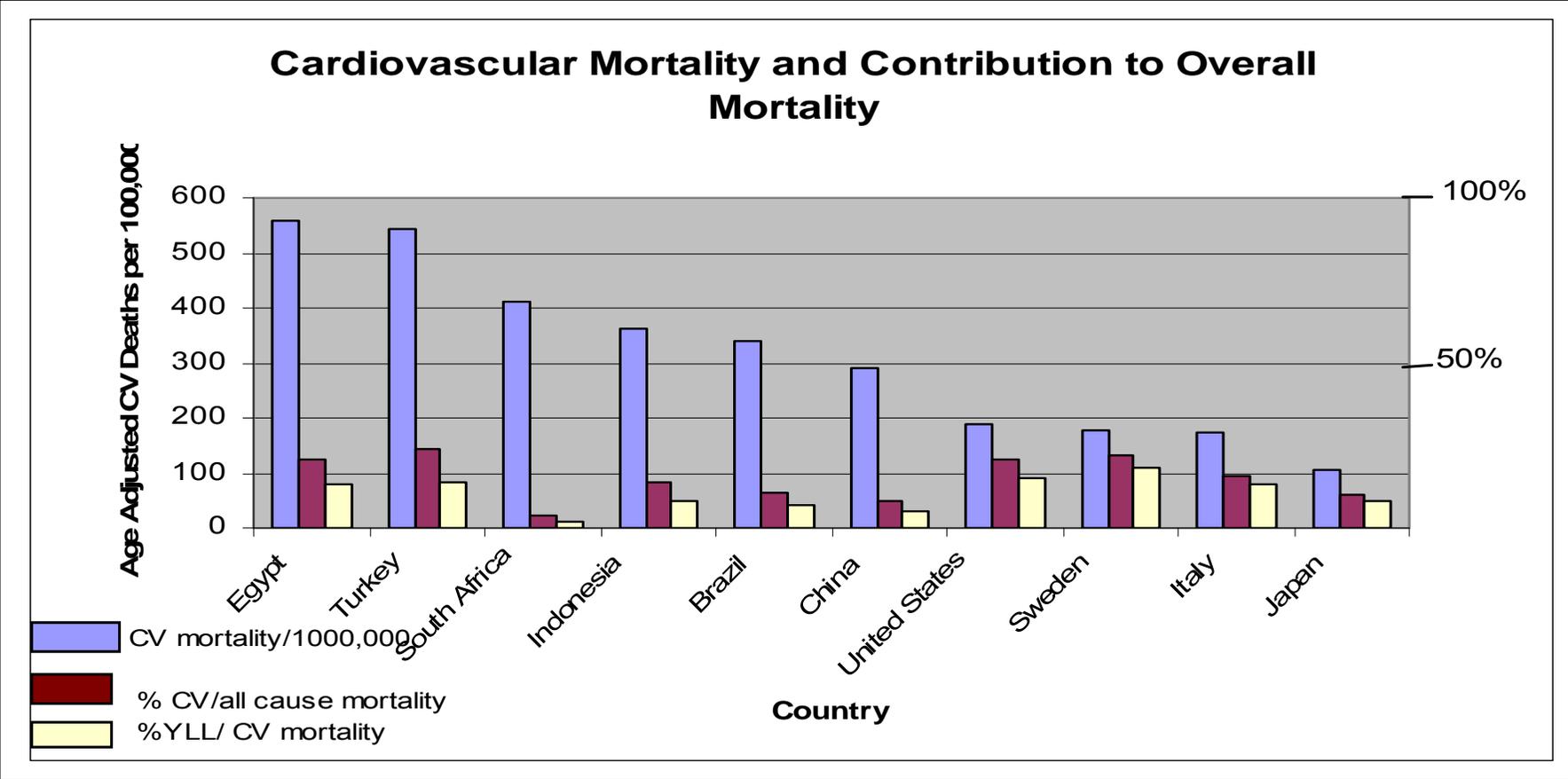


Figure 3.

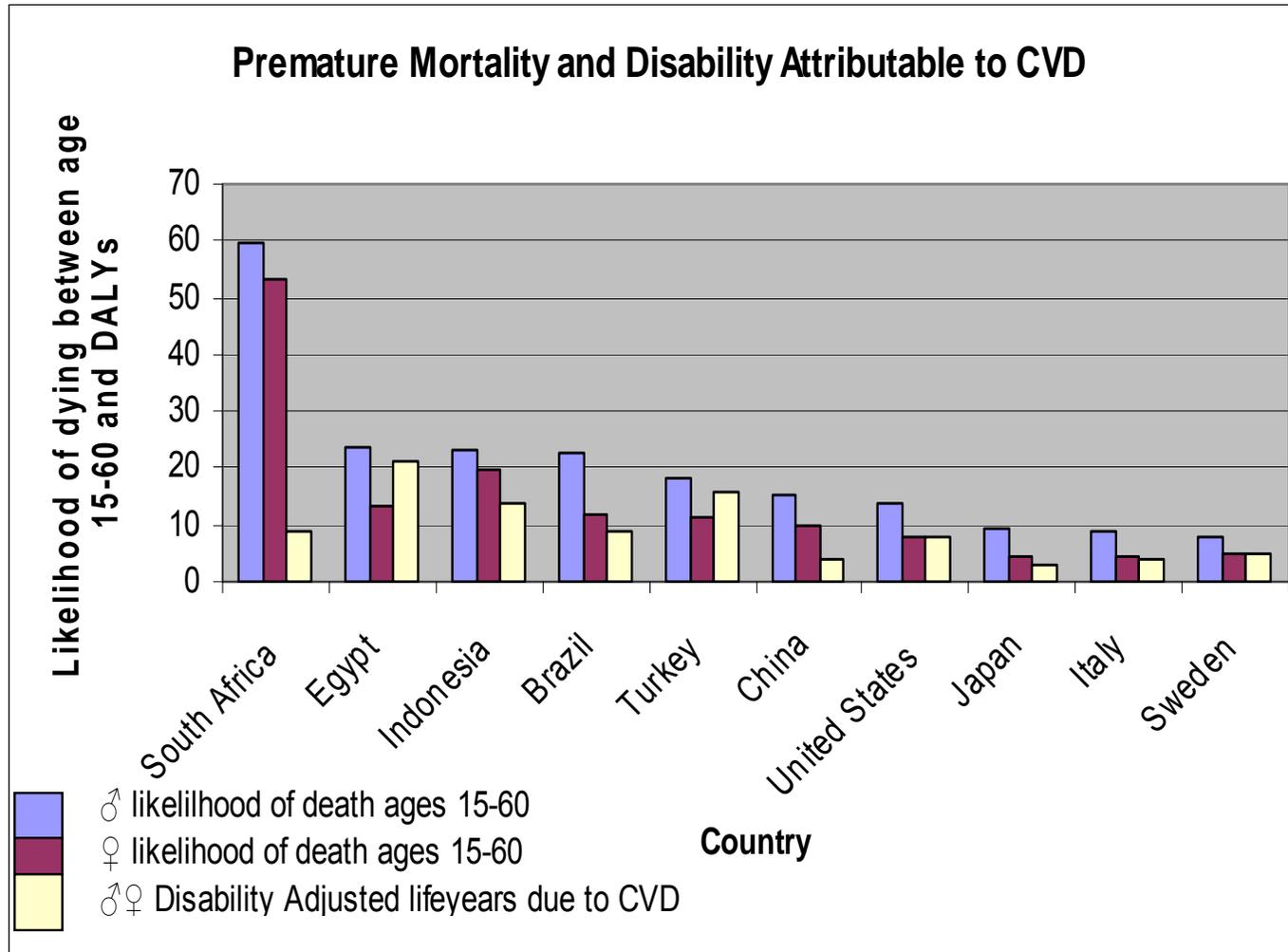


Figure 4.

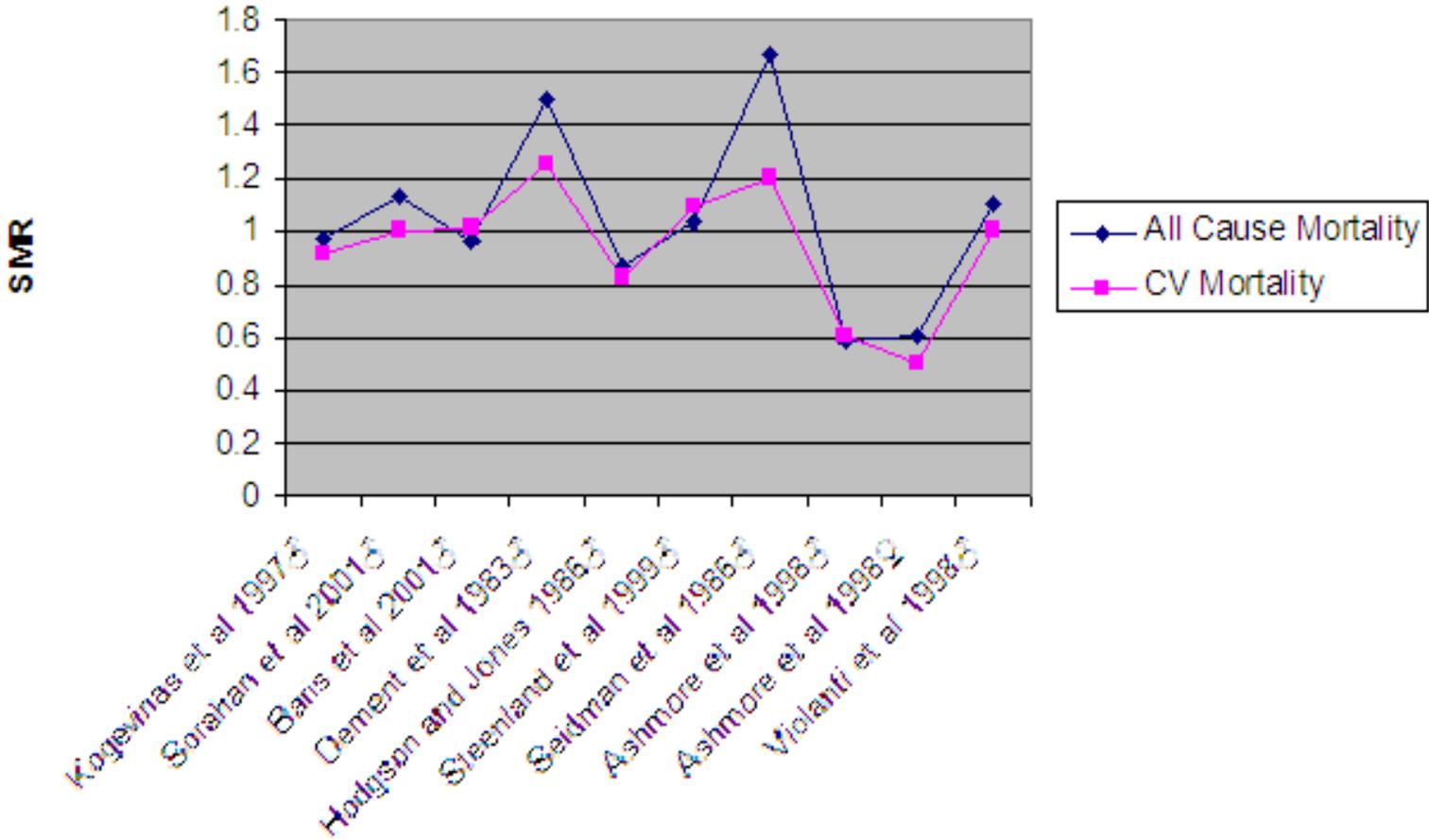


Figure 5.

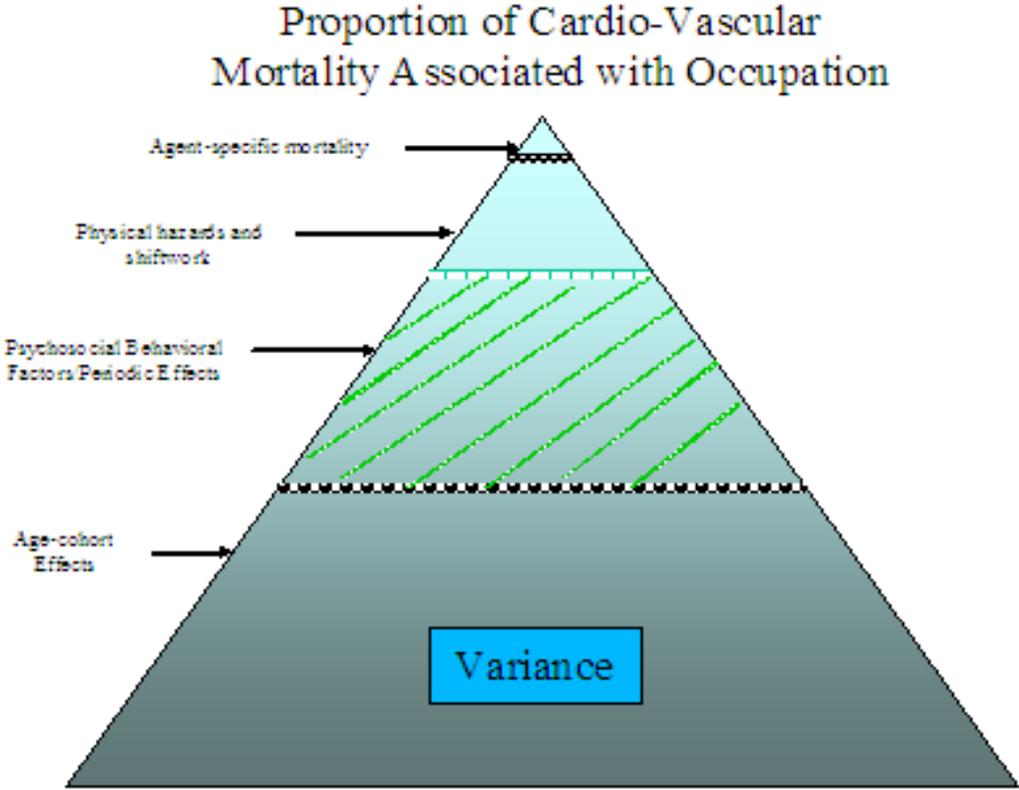


Figure 6.



Figure 7.

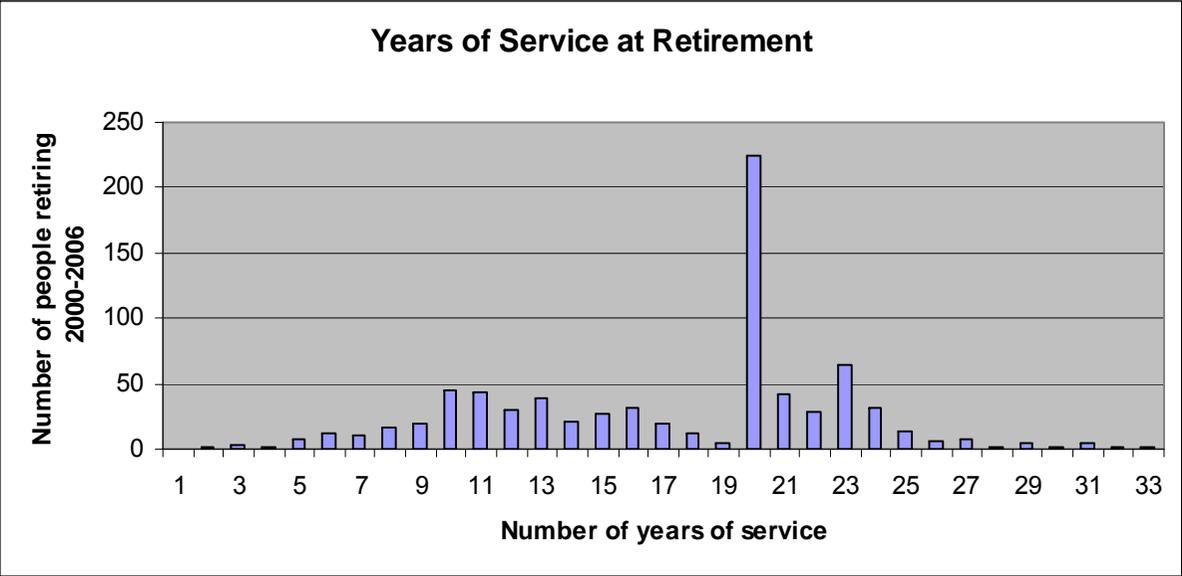


Figure 8.

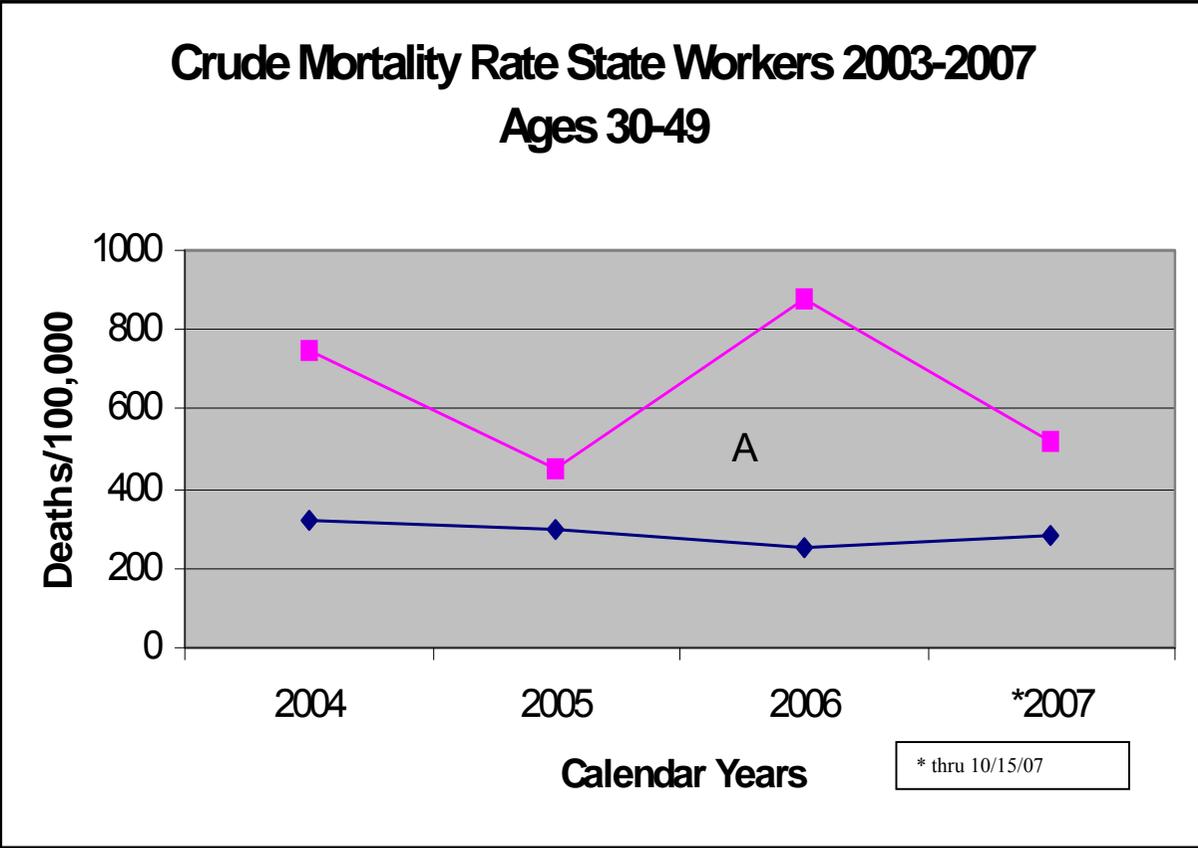


Figure 9.

