Globalization, Work, and Cardiovascular Disease

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Peter L. Schnall[1], Marnie Dobson[1], and Paul Landsbergis[2]

Abstract

Cardiovascular disease (CVD), a global epidemic, is responsible for about 30% of all deaths worldwide. While mortality rates from CVD have been mostly declining in the advanced industrialized nations, CVD risk factors, including hypertension, obesity, and diabetes, have been on the increase everywhere. Researchers investigating the social causes of CVD have produced a robust body of evidence documenting the relationships between the work environment and CVD, including through the mechanisms of psychosocial work stressors. We review the empirical evidence linking work, psychosocial stressors, and CVD. These work stressors can produce chronic biologic arousal and promote unhealthy behaviors and thus, increased CVD risk. We offer a theoretical model that illustrates how economic globalization influences the labor market and work organization in high-income countries, which, in turn, exacerbates job characteristics, such as demands, low job control, effort-reward imbalance, job insecurity, and long work hours. There is also a growing interest in "upstream" factors among work stress researchers, including precarious employment, downsizing/restructuring, privatization, and lean production. We conclude with suggestions for future epidemiologic research on the role of work in the development of CVD, as well as policy recommendations for prevention of work-related CVD.

[1]Center for Occupational and Environmental Health, University of California, Irvine, 100 Theory Way, Irvine, California, USA
[2]SUNY Downstate, Brooklyn, New York, USA

Corresponding Author:
Peter L. Schnall, Center for Social Epidemiology, 13650 Marina Pointe Drive, Apt. 1207, Marina del Rey, California 90292, USA.
Email: pschnall@workhealth.org

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Cardiovascular disease (CVD) is the foremost cause of morbidity and mortality in the world, accounting for about 30% of all deaths.[1] CVD results in the loss, on average, of 7 years of life expectancy in the United States.[2] In response, high-income industrialized nations have made massive expenditures on the diagnosis and treatment of CVD and its risk factors, such as hypertension, as well as—to a considerably lesser extent—public health interventions aimed at preventing and/or reducing CVD risk factors, such as anti-smoking campaigns. Both of these interventions, increased medical treatment of CVD risk factors and CVD, and anti-smoking campaigns have contributed to the reductions in coronary heart disease (CHD) mortality in developed countries.[3] However, the prevalence of CVD and its risk factors are increasing and constitute a growing public health pandemic both within the United States and worldwide. CVD is now the leading cause of death in all developing regions of the world except for sub-Saharan Africa.[1,4] Hypertension, obesity, and diabetes have also become global epidemics. Hypertension, as the leading contributing cause of CVD worldwide and the leading cause of stroke, affects more than 1 billion adults (26% of the world's adult population) and its prevalence is also steadily increasing worldwide.[5]

There is a broad consensus that coronary artery disease and stroke, as well as CVD risk factors such as hypertension and obesity, are not the "natural" results of aging, or of an aging population, but have environmental and social causes.[6–11] CVD and its risk factors are historically associated with the "epidemiological transition" from agricultural to industrial forms of production, urbanization, and subsequent changes in the nature of work, living conditions, diet, and physical activity and are patterned by social and economic inequalities.[10,12–19] We acknowledge that work is only one—though an important—social determinant of CVD and that additional pathways exist, including social and income inequality, non-work stressors (e.g., living conditions, family life), physical environmental exposures (e.g., air pollution), and certain health behaviors. However, we focus in this article on the substantial literature on the contribution of work, including labor market changes resulting from economic globalization, work organization, and work-related psychosocial stressors as social determinants of CVD and CVD risk.

CVD prevention efforts in public health have largely targeted individual-level health behaviors (e.g., smoking, weight loss) through community or workplace health promotion programs; legislative or regulatory approaches aimed at individuals, such as taxes on cigarettes; and environmental approaches, such as removing trans-fats or promoting physical activity

through changing the built environment during urban planning.[6,20] While these efforts are undoubtedly important, we additionally emphasize a framework for the primary prevention of CVD that focuses on "upstream" socioeconomic factors, including the need to transform the work environment to reduce unhealthy working conditions that directly and indirectly contribute to CVD and its risk factors.

Recently published theoretical papers highlight the importance of macro-meso-economic and social analytical levels in research on work and health.[21–23] A recent statement released by John Howard, the director of the U.S. National Institutes for Occupational Safety and Health, concludes similarly:

> Work as we know it in 2015 is dramatically different from the 9-to-5 certainty of full-time, uninterrupted, lifetime employment that most people in their twenties could expect a generation ago. The employment relationship is being transformed by various economic and organizational pressures not under the control of any one employer. These pressures arise from financial markets that incentivize corporations to shed all but their core business to contractors. Fierce competition in the globalized world of commerce pressures employers to structure work in the most efficient or leanest way possible... As the employment relationship continues to undergo change, stress related to work organization, scheduling, and staffing may heighten risks for worker injury or illness.[24]

We build on these theoretical frameworks that focus on a broader understanding of the way in which economic globalization may contribute to the changing nature of work in advanced industrialized countries and to stressful working conditions contributing to poor health, including CVD and its risk factors.

First, we briefly discuss how CVD is a disease of "modern industrial society" related to forms of production that emerged with industrialization: repetitive work, low-control assembly line jobs, and wage labor, among others. We briefly evaluate the large body of empirical evidence from more than 30 years of psychosocial epidemiological studies linking work organization and stressful job characteristics to CVD and CVD risk factors and discuss the possible mechanisms.

Second, we advance a theoretical "socio-ecological" model (see Figures 1 and 2) that is consistent with current knowledge on possible pathways and mechanisms and that illustrates policies associated with "neoliberalism" that have advanced a globalized economic system, changing labor markets, and working conditions in advanced industrialized countries with subsequent increases in exposure to stressful work.

Third, we highlight those areas on which epidemiologists and other social scientists interested in globalization, work, and health could focus future

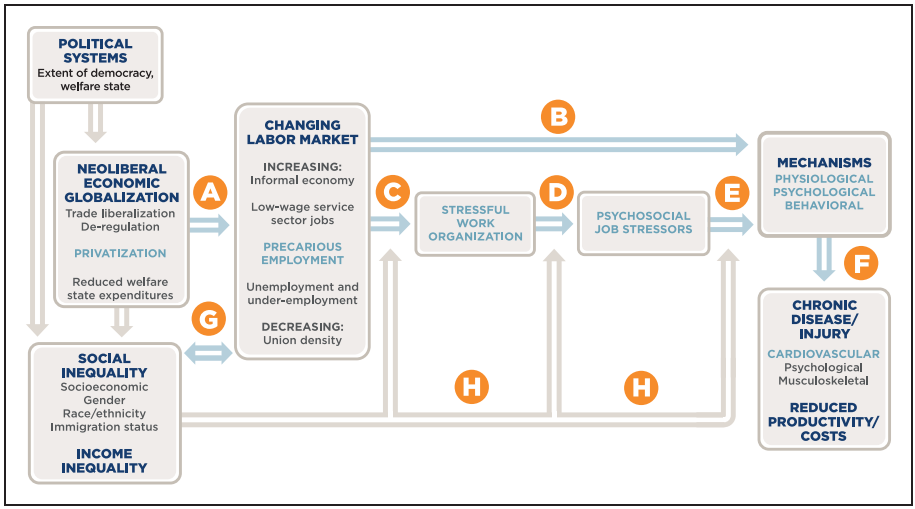

Figure 1. Macro model of globalization, the changing nature of work and health. Evidence for variables highlighted in light blue provided in this article. Proposed pathways have been lettered A-H. Adapted from: Landsbergis P, et al. Occupational Health Psychology (pp. 1086–1130). In Anna D (ed.) The Occupational Environment (3rd ed.). American Industrial Hygiene Association, 2011.

research, to better identify and analyze the "upstream" influences on unhealthy working conditions and their relationship to CVD.

Lastly, we argue that our analysis supports the necessity of public health interventions and national legislation aimed at creating healthier work environments, along the lines of the EU-OSHA and World Health Organization Healthy Workplaces framework,[25] as a critical part of a total public health strategy for the prevention of CVD.

CVD, Industrialization, and the Epidemiological Transition

There is a consensus that CVD incidence is linked to a country's stage of economic development.[1,4,6] The social and economic transitions that occurred in the 18th and 19th centuries transformed "Western" countries from rural and farming-based economies to primarily urban and industrial. One of the consequences of economic development and industrialization in "Western" countries was the emergence in the 20th century of chronic diseases replacing infectious diseases as the primary causes of mortality, known as an "epidemiologic transition."[26–28]

Such a transition is now being replicated in many developing countries. The social and economic changes associated with this transition also allowed for and accelerated the emergence of cigarette smoking, elevated cholesterol, obesity, diabetes, and hypertension, all recognized as major risk factors for CVD.

Hypertension, now the leading cause of CVD worldwide, accounts for 54% of deaths from stroke and 47% of ischemic heart disease.[5] Identified risk factors—including obesity, sodium, alcohol, genetics, and age—explain only a small part of the risk of hypertension.[29] Cross-cultural anthropological studies have consistently found that non-industrial societies, such as hunter-gatherers, have a very low prevalence of hypertension and that blood pressure does not inevitably rise with age as it does in industrial societies.[30–32] While obesity and salt intake are risk factors for hypertension, many people with hypertension are not overweight,[33] and sodium intake appears to be a necessary but not sufficient factor for the elevation of blood pressure.[34] Hypertension, still considered a disease of "unknown etiology"[35] after more than 100 years of research, has recently been acknowledged by the American Kidney Foundation to be the result of "lifestyle changes related to industrialization and urbanization."[36] Social determinants associated with industrialization, including urban lifestyles and working conditions, may help to explain the emergence in the past 100 years of hypertension as a pandemic that will soon afflict 1.5 billion persons.

Industrialization not only changed the nature of work, but also living conditions (e.g., rural to urban) and diet, and created more sedentary lifestyles and industrial pollutants. Craft-based and agricultural work conducted by family units or craft communities were transformed by new forms of industrial manufacturing, which took workers away from their families and paid them wages to work in factories, producing materials and goods on assembly lines where work was repetitive and largely unskilled. Frederick Taylor introduced the earliest form of "scientific management" in these new workplaces.[37] Along with Fordism, Taylorism dominated manufacturing into the 1930s. "Scientific management" approaches involved the scientific study of manufacturing processes in order to create the most efficient, productive, and profitable system. Its roots continue to be part of most modern production practices, where task-level optimization of workflows is ubiquitous. Critics of these systems pointed out the lack of attention to "human resources," and studies in the 1960s, 1970s, and 1980s called attention to the resultant alienation from work over which the individual has little control. The study of these changes to work processes and the effects on human well-being largely focused on the impact of highly demanding, machine-paced, monotonous, and repetitive work. More than 30 years of epidemiologic research has explored the role of control over how to perform work tasks and other work processes on physical and mental health.

Psychosocial Work Stressors, CVD, and CVD Risk Factors

A major breakthrough in our understanding of the role of working conditions in the etiology of CVD came in the late 1970s with the development of the "job strain" model, now the most frequently studied type of work stressor. "Job strain" is defined as work that combines high psychological job demands with low job decision latitude or job control.[38] A second psychosocial work stressor model, "effort-reward imbalance" (ERI), was proposed in the 1990s and hypothesizes that a "mismatch between high workload (high demand) and low control over long-term rewards" is a stressor (Figure 2, Arrow E).[39, p.1128] Low reward includes low "esteem reward" (respect and support), low income, and low "status control" (poor promotion prospects, employment insecurity, and status inconsistency). ERI links "the structure of social opportunities with well-being and biological functioning via distinct types of stressful everyday experiences" (p. 1034) and combines sociological theory with psychosomatic and behavioral medicine.[40, p.1034] A robust body of research in psychosocial epidemiology documents that psychosocial stressors such as job strain and ERI are an important pathway in the development of CVD, involving the chronic activation of the stress response[22,38,41,42] (see Figure 2, Arrows D, E, F).

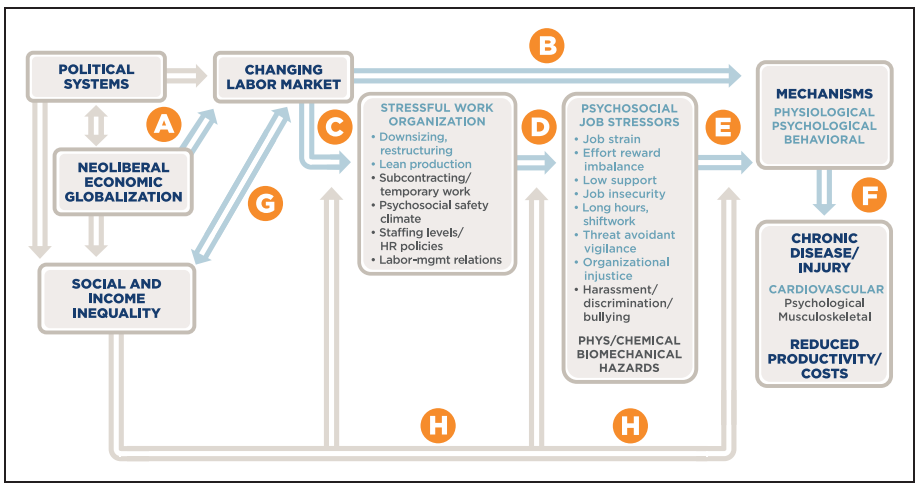

Figure 2. Micro model of globalization, the changing nature of work and health. Evidence for variables highlighted in light blue provided in this article. Proposed pathways have been lettered A-H. Adapted from: Landsbergis P, et al. Occupational Health Psychology (pp. 1086–1130). In Anna D (ed.) The Occupational Environment (3rd ed.). American Industrial Hygiene Association, 2011.

Cardiovascular Disease

Most reviews and meta-analyses of research on job strain and CVD (including some recent evidence on stroke) find strong evidence of a positive relationship (see Online Appendix [joh.sagepub.com/supplemental]). While there have been fewer studies of ERI and CVD, in 2005, Johannes Siegrist reviewed 11 prospective studies utilizing the ERI model and concluded that those with ERI at work are twice as likely to suffer from incident CVD. A positive statistical association was also confirmed in a recent review of prospective cohort studies of ERI and CVD (see Online Appendix). A number of prospective studies have also found associations between returning to work to a job with job strain or ERI after having had a heart attack and a higher recurrence of coronary heart disease or myocardial infarction (MI) (see Online Appendix).

In March 2013, the Sixth International Conference on Work Environment and Cardiovascular Diseases, under the auspices of the International Commission on Occupational Health (ICOH) Scientific Committee on Cardiology in Occupational Health, in Tokyo, Japan adopted a statement following publication of the Individual Participant Data (IPD) Work Group results on job strain and CVD in *The Lancet*.[43] The Tokyo Declaration concluded that 80% of all CVD mortality is preventable if existing knowledge is effectively applied and that "according to research data 10%–20% of all causes of CVD deaths among working age populations can be attributed to work, i.e. are work-related" (p. 4).[44]

Blood Pressure and Hypertension

The work environment is where adults spend the majority of their waking hours, and blood pressure measured with portable ambulatory blood pressure (ABP) monitors is elevated during work hours relative to non-work hours.[45–47] Work activities characterized as demanding and over which workers have little control or autonomy can provoke sharp rises in blood pressure under experimental conditions.[48–50] We also know that those occupations that require constant threat-avoidant vigilance (TAV) (i.e., a high level of vigilance in order to avoid serious accidents and loss of human life) lead to increased levels of biological arousal.[51] Occupations with TAV include urban bus drivers, air traffic controllers, and firefighters and are observed to have some of the highest prevalence rates of hypertension of all U.S. occupations.[52,53] More research is needed on the specific features of these occupations and the mechanisms by which they contribute to the development of hypertension.

ABP is a much better predictor than casual clinic BP of target organ damage[54,55] and incident CVD.[56–58] The first study of job strain and ABP, the New York City Work Site Blood Pressure Study, showed that men with job strain had higher levels of work, home, and sleep ABP and increases in the size of their heart's left ventricle (a sign of damage to the heart) after taking into

account other risk factors, such as age, race, and body mass index, than men without job strain (see Online Appendix). A quantitative meta-analysis and systematic review of prospective and cross-sectional studies of job strain and ABP concluded that job strain is a risk factor for BP elevation.[59] Given the limitations of casual clinic BP as a measure of a person's true average daily BP, weaker associations between job strain and casual clinic BP would be expected;[59,60] however, despite this limitation, Gilbert-Ouimet and colleagues found a positive association between job strain and office BP in a review (see Online Appendix). Several prospective studies and a 2014 review of the literature on ERI and BP level found that a majority of studies observed a significant association with either blood pressure or hypertension (Figure 2, Arrow E) (see Online Appendix).

CVD Behavioral Risk Factors

There is also evidence that psychosocial work stressors (job strain or ERI) promote unhealthy behaviors that increase the risk for CVD, such as cigarette smoking, alcohol consumption, physical inactivity,[61–65] and stressful eating, leading to weight gain and obesity (Figure 2, Arrows E, F) (see Online Appendix).

BMI and Obesity

There is strong evidence that changes in working conditions, particularly sedentary labor, play a role in the development of obesity by the mechanism of reduced caloric expenditure (Figure 2, Arrow B). The more hours spent at work in a sedentary job, the heavier working people are.[66] There is a recent and growing literature presenting evidence of associations between job strain and ERI and BMI or weight change (see Online Appendix). However, more high-quality longitudinal studies of work stressors and obesity are still needed (Figure 2, Arrow E). Work stress may also influence weight gain directly through disturbance of circadian rhythms (e.g., sleep disturbances due to shift work or long work hours) and hyper activation of the hypothalamic–pituitary–adrenocortical (HPA) axis and metabolic changes (neuroendocrine pathway).[67,68]

Diabetes and Metabolic Syndrome

Given the observed relationships between job strain, high blood pressure, and obesity, it is perhaps not surprising to find increasing and strong evidence that job strain is a risk factor for diabetes and the metabolic syndrome (Figure 2, Arrow E, F), although there is less sufficient evidence for ERI (see Online Appendix). There is a credible biological link between stress at work and the

development of Type II diabetes, which is characterized by insulin resistance. Brunner and colleagues argue that cortisol "stimulates glucose production in the liver and antagonizes the action of insulin in peripheral tissues" and that there is evidence of an increase in cortisol secretion after waking in those reporting high stress at work.[69]

Work Stressors, Depression, and CVD

There is a large literature showing associations between job strain, ERI, job insecurity, and depression or depressive symptoms.[70–77] This has important implications for the theoretical models of work stress and CVD, because there is also a growing literature supporting a causal link between depression and the development of CVD (Figure 2, Arrows E, F).[78–81] Depression and depressive symptoms most likely have a direct effect on the development of CVD through activation of the hypothalamic-pituitary-adrenal axis, diminished heart rate variability (HRV), ventricular instability and myocardial ischemia in reaction to mental stress, and alterations in platelet receptors and/or reactivity,[78,80,82] though whether this is due to depression or the work stressors' contribution to depression and CVD is still not clear. Another proposed mechanism is an indirect association between depression and CVD. Work stressors may lead to depression, which may also be associated with unhealthy behaviors including smoking, alcohol, or lack of exercise, which are related to CVD.[77] Some evidence also exists that "work-related" burnout—often a precursor to depression—is associated with cardiovascular reactivity and CVD.[83–85]

Limitations of Psychosocial Work Stressor Research

The research that has been conducted over the past 30 years on psychosocial work stressors and their impact on mental and physical health has also increased our understanding of the difficulties and limitations in conducting such research and the likely consequences to both the strength of association and the validity of these findings. Gaining access to worksites in the United States is difficult because many companies resist studies that document links between work organization and health, and U.S. government funding of studies of work organization and health is quite limited. This is also true in most developing nations, where there is limited research on work stressors due to a lack of resources. Typically, cross-sectional studies of single occupations are common. These studies have serious limitations as psychosocial exposures have limited variance within an occupation (e.g., workers on production lines do similar tasks), limiting the discoverable relationship between exposure and outcome. Cross-sectional studies are less valid than longitudinal studies, the latter being both more difficult to conduct and expensive, and cross-sectional studies cannot provide information on important issues such as incubation or latency periods nor

clarify the effect of duration of exposure. However, recently we are seeing some strong prospective studies and meta-analytic evidence. Effect estimates vary based on how exposures are modeled (e.g., use of job strain quadrant model vs ratio term) and there are many biases toward the null value in these studies, which produce underestimates of effect.[86,87]

We know that the type of government, including legislation and regulations, affects exposure rates and that these differences from country to country and by region of the world could impact effect estimates and population attributable risk.[88] This may account, in part, for the many inconsistent findings based on groups, particularly differences in findings between men and women and between countries. Finally, we note that many psychosocial work stressors, such as work-family spillover, organizational justice, psychosocial safety climate, and bullying, are all understudied exposures in relationship to CVD and their eventual inclusion in future studies are likely to clarify causal relationships.

"Bio-Psycho-Social" Mechanisms: How Work Stress "Works"

The medical explanation for the CVD epidemic is one that generally holds individuals ultimately responsible for their health and conceives of illness as a combination of individual vulnerability (i.e., family history, genetics) and unhealthy behaviors. The medical model mostly ignores social ("upstream") causes of disease, such as socioeconomic status and working conditions, or minimizes their importance when acknowledged. However, as discussed earlier, research finds that workers are increasingly exposed to an array of organizational demands and psychosocial work exposures, at the core of which are limitations of individual control over the working environment. The psychosocial stressor measures described herein tap into a general sense of powerlessness, both individual and collective, stemming from historical and contemporary social transformations, including workplace changes. Nearly every psychosocial work stressor assesses control at some level. For example, the job strain model's control dimension is operationalized as decision latitude over work processes, while for ERI it is measured as control over job security and opportunities for advancement.

The role of psychological processes, such as job control, in triggering the stress response represents a significant departure from and expansion on the original concept of homeostasis that was focused on how physical stressors led to disease.[89] The biological arousal that occurs in individuals due to psychological stress resulting from lack of control or inadequate resources to meet demands was first described by Eyer and Sterling in 1984 and named allostasis.[90] "Allostatic load," a conceptual extension of allostasis developed by McEwen and Stellar in 1993,[91] represents "the wear and tear on the body"[90] that is the physiological consequences of chronic exposure to fluctuating or

heightened neural or neuroendocrine response that results from repeated or chronic stress.[92]

The concept of allostasis aptly captures the observed relationship between stressful work exposures such as job strain, ERI, and job insecurity and the body's signs of arousal, such as elevated blood pressure or increased cortisol levels. The concept provides an explanatory mechanism whereby employment and working conditions that create psychosocial stressors in turn provoke both psychological responses and physiological arousal in workers.[89] The arousal contributes gradually over time to chronic changes in human physiology and ultimately leads to anatomic changes such as thickening of artery walls (due to hypertension)[93–95] or to atherosclerosis (leading to CHD).

In addition to causing biological arousal, work-related psychosocial stress may also contribute to behaviors that are CVD risk factors, such as cigarette smoking, alcohol consumption, and stress-eating and low levels of physical activity contributing to obesity. Psychosocial work stressors may therefore also affect CVD indirectly through these health behaviors, although results are not always consistent and additional longitudinal research is needed.[96]

Work stress exposures vary with the changing nature of work, changes in an individual's occupation, changes by an individual within the same occupation (e.g., promotions), and the individual's life course.[97] Therefore, the impact of work stressors on the body will most often be gradual and subtle, and health outcomes, such as increasing blood pressure and atherosclerosis, may take many years to develop. Conversely, it seems likely that it would take considerable time to reverse the changes that result from chronic exposure—that is, if reversibility is possible after a certain degree of anatomical change has occurred. The NYC Worksite ABP study demonstrated a 4–5 mm Hg fall over a 2-year period in ABP among participants reporting a change from job strain to no strain.[98] What remains to be fully demonstrated is whether reducing stressors at work will lead, over time, to a more comprehensive reversal of the biological consequences of stress. Despite the limited evidence to date on the impact of lowering job strain on BP, there is extensive evidence that it is possible to change job characteristics and work organization and that there is a growing literature showing the effectiveness of workplace interventions to reduce work stress.[87,99,100]

Economic Globalization: Recent Trends Affecting Work Stress and CVD

Economic globalization is characterized by the increasing interdependence of national economies, involving the cross-border movement of goods, services, technology, and capital that has escalated since the end of World War II. Some scholars argue that while processes of industrialization have been

occurring globally for some time, the relationships between states and economic elites have recently become more closely aligned, leading governments globally to support their interests over the interests of the middle and working classes.[101] The economic philosophy of neoliberalism can be traced in its most recent incarnation to the Thatcher and Reagan eras of the 1970s and 1980s. It calls for not only "free trade" (reduced tariffs on goods) but also to conservative fiscal economic policies, including reduction of government spending on education, welfare programs, and health care; privatization of the public sector; and deregulation of occupational and environmental health and financial sectors[102–105]—all of which are seen as obstacles to private-sector investment (see Figure 1) and subsequent economic growth.

As a result of policies associated with neoliberalism, the past several decades have seen a systematic removal of trade barriers and accelerating direct foreign investment in developing economies.[103–105] This led initially to sustained growth in per-capita gross domestic product in both developing and developed countries since the 1970s, though recently growth has been slowing globally.[102–105] While proponents of globalization[106,107] argue that economic globalization has been associated with reductions in poverty and improvements in standards of living and health indicators, such as decreasing infant mortality and improved life expectancy in the developing world, critics argue that there have been many unintended consequences, including a rise in the incidence and prevalence of chronic diseases in developing countries, not solely due to increased life expectancy (see Figure 1, Arrow H),[108,109] and increasing income inequality. Perhaps contributing to these epidemics, over the last 30 years, income inequality has been increasing dramatically in many countries, including the United States and the United Kingdom.[110,111] In some advanced industrialized countries, such as the United States, there has also been a large decline in the strength of the labor movement resulting from the erosion of unionized blue-collar manufacturing jobs,[112] an expansion of the non-union service sector, and political opposition from employers (see Figure 1, Arrow A). The weakened bargaining power of labor in the workplace, economy, and political system contributes to growing income inequality and social inequality (Figure 1, Arrow G),[109,113,114] "free trade" agreements, more precarious work, and ever more increasingly stressful working conditions (Figure 1, Arrow A).

Neoliberal economic globalization is not only having an enormous impact on wealth and income distribution, but also on labor markets, work organization, and the health of working people (Figure 1, Arrows A-E). Competition between companies due to increasingly scarce energy and other resources, together with the ongoing market demand for corporate profitability, drives globalization, new technology, and changes in workplace organization.[102,112,115,116] Such changes include outsourcing of manufacturing jobs and, more recently, service jobs from the advanced industrialized countries to "free trade zones" (FTZs)

established in developing countries in Mexico, Latin America, and the Philippines and, more recently, in China and India, which are exempt from government regulations and supported by tax codes that allow corporations to avoid paying taxes on profits from these FTZs.[102] Partly as a consequence of this, the advanced industrialized nations have seen mass layoffs, restructuring, and downsizing of more expensive labor pools in the United States and Europe. This has led to a higher prevalence of precarious work, "contingent work," increased job insecurity, and increased time pressure and intensification of work (see Figure 1, Arrow A,C).[114,117,118] Benach and colleagues have extensively evaluated the impact of globalization and concluded that it "has increased the inequality in working conditions across regions, countries, social groups, and occupations" and has "generated substantial social inequalities in health."[119, p.1392]

To further enhance "efficiency," productivity, and profitability, new systems of work organization are always being implemented in manufacturing (see Figure 1 and 2, Arrow C). Originally developed by Toyota in the 1950s, the predominant new system is "lean production," "total quality management," or "just-in-time management," which are versions of scientific management or "Taylorism."[120,121] Lean production is characterized by management practices intent on ending "wasteful" production processes to gain greater efficiency and quality. On the positive side, some tasks and responsibilities are transferred to teams of workers with the central principle of providing job rotation and "multi-skilling" to ease the "mind-numbing stress" of previous mass-production assembly lines.[122] However, rather than being a form of "worker empowerment," studies have shown that in many workplaces, workers are frequently subject to tighter supervision, surveillance, multi-tasking (rather than multi-skilling), and less control and consequently experience increased stress (see Figure 2, Arrow D).[120] "Lean" management philosophies have recently spread to health care, social services, government work, and other primarily white-collar industries.[123]

With the most recent global economic crisis in 2008 and a worldwide slowing in economic growth, there is evidence that working conditions are further worsening.[114,124] With the rise of the new "flexible labor market," precarious employment has been on the increase in advanced industrialized countries, with predictions that it could involve more than 40% of the labor force (see Figure 1, Arrow A).[125,126] Layoffs and high unemployment in the United States and Europe as a result of the recent economic crisis have also contributed to the rapid rise in precarious labor, characterized by non-standard employment arrangements, as compared to the post- World War II world of permanent, full-time jobs with benefits.[114] Non-standard work, which may soon become "standard," is characterized by increases in involuntary part-time work; short-term contracts, often without benefits; and more unregulated "underground" or "home-based" work (see Figure 1, Arrow A).[117,127–131]

We document below some of the most recent and significant labor market and work organization changes resulting from economic globalization in the last 20 to 30 years and highlight some of the evidence published to date investigating the likely links to increased psychosocial stressors and CVD or CVD risk.[23,117,129,131–139] Research findings suggest that precarious employment may increase CVD risk factors (Figure 1, Arrow B, F) or may produce increased exposure to psychosocial work stressors, such as higher workloads, lower job control, lower work-related social support, and job insecurity (Figure 1, Arrow C, D).[117] These psychosocial stressors, in turn, contribute to increasing the prevalence of CVD risk factors, such as high blood pressure, physical inactivity, obesity, and diabetes (Figure 2, Arrows D, E, F).

Precarious Employment, Organizational Restructuring, Downsizing, and Job Insecurity

More flexible work hours may benefit some workers; however, the rise in precarious employment arrangements, including increased involuntary part-time work, temporary contracts, and "independent contractors," amplifies vulnerability, especially in the presence of an inadequate social safety net, and is associated with greater job stressors due to greater job insecurity, work intensification, and lower control over work schedules and the work environment (Figure 1, Arrows C,D).[118,140] Organizational restructuring and downsizing can lead to anticipation of job loss and to greater job demands among survivors or those working on temporary contracts alongside permanent workers and potentially competing for full-term permanent contracts.[117,129,141–143] Perceived job insecurity, a central construct in "precarious employment," is thought to act as a chronic stressor giving rise to adverse health outcomes (see Figures 1 and 2, Arrow B). The construct has been operationalized in the Precarious Employment Scale and includes contract duration, low or insufficient wages, vulnerability, workplace rights, and the exercise of those rights.[143] These "precarious" employment arrangements differentially affect those who are among the poorest and most vulnerable working populations (e.g., low income, women, immigrant, and non-white), leading to increased social inequality and occupational health disparities (Figure 1, Arrows G, H).

Impact on Health. Recent studies have shown an association of precarious employment, downsizing, and job insecurity with poor physical and mental health, sickness absences, or disability pensions (Figure 1, Arrow B).[131,135,143–149] Benach et al.[117] conducted a systematic review of a growing number of studies that show associations between precarious employment (e.g., downsizing/restructuring) and CVD.[139,150,151] Migration to find better work and living conditions, a form of precariousness, has also been linked to increased stress and to risk of hypertension, obesity, and diabetes.[152]

Privatization and Increased Precariousness

Privatization of the public sector has been a distinctive part of neoliberalism and economic globalization.[102,153] Many industries have been affected by privatization as a result of neoliberal economic policies, including transportation, telecommunications, utilities, and some government sectors.[104] Privatization and resulting restructuring has impacted labor markets, resulting in job loss and other forms of precariousness (Figure 1, Arrow A).[154]

Impact on Health. There is, at this time, limited research examining the association between privatization and risk of CVD (Figure 1, Arrows A, B). The British Whitehall study of U.K. civil service agencies (some privatized between 1990–1993) shows some evidence of a relationship between privatization and risk of CVD (see Online Appendix).

Lean Production and New Public Management

While highly promoted as a method for improving efficiency and productivity, lean production methods frequently result in greater work intensity and a lack of meaningful influence at work (Figure 2, Arrow D).[120,155,156] Lean production methods have also begun to appear in the health care industry and in the public sector, as reduced budgets have pressured public agencies to increase productivity. Often called "new public management," this form of lean work has resulted in intensive performance monitoring and metrics and work intensification (rising demands), lower decision latitude, and increased job insecurity in many public-sector jobs.[123,157,158] A review of an additional 15 studies published since 1999 has similar findings to previous reviews, including increased psychological distress, increased high job demands, and low or reduced levels of job autonomy, authority, or participation.[156]

Impact on Health. A few studies show increased risk of psychological distress and musculoskeletal disorders in workers in "lean" jobs.[120,155,156] Unfortunately, there have been no studies of the impact of lean production on CVD risk. We posit that lean production, along with other "upstream" work organization factors, would affect CVD risk factors such as blood pressure through its exacerbation of stressful work characteristics (Figure 2, Arrows D, E, F). Innovative research on the association between forms of lean work and CVD risk factors and CVD is urgently needed.

Long Work Hours, Shift Work, and CVD

Researchers in Japan have identified a relationship between long work hours and sudden death, which they call Karoshi.[159–161] A growing body of both

prospective and cross-sectional evidence demonstrates a substantial elevated risk of CVD with long work hours (see Online Appendix). An additional concern is that individuals in jobs with both long work hours and exposures to job strain and other work stressors may experience greater cumulative exposure and have their disease process accelerated (Figure 2, Arrows D, E, F). Several recent studies have shown positive associations between shift work, overtime, or long work hours and obesity or BMI (see Online Appendix).

Research Directions and Recommendations

A consensus has emerged among occupational health researchers based on the weight of scientific evidence, some of which we have described above, that employment and working conditions are a significant "upstream" influence on CVD.[44] Given the general agreement that work factors play an important role in the development of CVD, it is reasonable to conclude that the workplace and the organization of work should be a target of primary prevention of CVD and CVD risk factors. Further research on the "causes" of job strain and effort-reward imbalance and other unhealthy psychosocial stressors is needed in order to ascertain potential "upstream" or distal intervention points. For example, recent research on psychosocial safety climate, the extent of management concern for workers' psychological health, is in the beginning stages.[162] A recent study of Australian workers estimated the population attributable risk finding that improving an organization's psychosocial safety climate could reduce 14% of job strain and 16% of depression in this working population.[163]

Research in social and occupational epidemiology, exemplified by the excellent efforts of Muntaner and Benach and their colleagues, among others,[23,134] is only beginning to assess the effects of global economic changes on work processes (especially outside of high-income countries) and to investigate the mechanisms for the creation of psychosocial work stressors. Evidence is strong of the relationship between psychosocial work stressors, especially for job strain and ERI and CVD and some CVD risk factors, particularly blood pressure, in part because these exposures have been extensively studied. However, we need more comprehensive studies of the role of macroeconomic and meso-social work organization factors—especially precarious work, privatization, downsizing, lean production, decreasing union density, and work intensification—on workplace stressors and CVD.

In light of the existing evidence that working conditions impact CVD health (among other outcomes) and our conclusion that these conditions are both socially constructed and malleable, we discuss next what further research is needed and then what role social and occupational epidemiology might have in influencing legislation, regulation, and public policy regarding workplace protections that could be enacted to reduce unhealthy work and to help prevent CVD.

What Further Research is Needed?

First, we need better data on the prevalence of exposures and outcomes by occupation. National surveillance data is ideal for determining the magnitude and distribution of unhealthy working conditions in order to formulate better public policies regarding these exposures and their association with chronic illnesses. Europe has extensive national data on working conditions. In the United States, national surveillance systems such as the National Health and Nutrition Examination Survey and the National Health Interview Survey have little data on work organization and psychosocial stressors. A short occupational health supplement to the National Health Interview Survey has been included in 1988, 2010, and 2015. In addition, the U.S. National Institute for Occupational Safety and Health has conducted national Quality of Worklife Surveys in 2002, 2006, 2010, and 2014. However, as a result of limited budget and staff, results from these surveys have not been routinely reported.

In the United States, a national surveillance system is needed that could provide epidemiologists the ability to measure the prevalence of psychosocial stressors by occupation and job title and to explain relationships and target interventions. While the economic cost of creating and carrying out a national work conditions surveillance project would be substantial, the ultimate benefits of reduced illness and treatment costs due to identifying high-risk populations for targeting interventions will most likely be much greater. We recognize that many businesses may resist and lobby against such a surveillance system, due to the potential economic costs to businesses of increasing the proportion of chronic disease that is recognized and compensated as work-related.

There is an even greater need for more assessment of the prevalence of workplace stressors in low- and middle-income countries, especially because much of the evidence implicating the role of working conditions in causing CVD comes from Europe, where work psychosocial stressors are regulated and thus working conditions are "healthier" than in developing countries. Unfortunately, there are few resources in low- and middle-income countries for national surveillance, exceptions being the national working conditions surveys in Taiwan[164] and South Korea,[165] though early efforts are underway in several Latin American countries. Researchers in developing countries will often need to collaborate by combining the results of their smaller studies into a national dataset—a type of "individual-level" meta-analysis. Alternatively, a job exposure matrix method based on data from national surveys, where they exist, could be used to impute exposure to job stressors to individuals and groups within occupational categories when data on job characteristics for individual workers is not available but occupational title is.[166]

Second, we need to deepen and further clarify our understanding of the relationships between labor market changes and economic globalization and the resulting changing nature of working conditions. We also need to continue

the process of identifying and clarifying the links among work organization, workplace stressors, and health outcomes. Epidemiologists need data to link trends in precarious employment, privatization, or downsizing to trends in the prevalence of psychosocial stressors and changes in health outcomes. Because working conditions vary with time and with economic and national context, as well as specific occupational settings, individual exposure will also vary, and the impact on the human body will often be gradual and subtle because, as previously mentioned, outcomes such as hypertension or atherosclerosis take years to develop. Thus, studies of work stressors require longitudinal designs of representative populations with lengthy follow-up periods utilizing repeated measures of both exposures and outcomes, an investment that would surely pay rich dividends in terms of improved worker health and reduced medical costs.

Third, while the evidence of a link among work factors, CVD risk factors, and CVD is growing clearer and stronger, more intervention studies using varying designs are needed to better understand the best methods and targets of intervention to ameliorate work stressors. There are examples of well-designed intervention studies outside of the United States that have shown effective reductions in job stressors or work organization leading to changes in health indicators, including a decrease in blood pressure among Stockholm bus drivers[167] and improvements in job characteristics and reductions in burnout and depression in Quebec hospital workers.[168] Because it is likely that it will take considerable time to reverse physiological and anatomical changes resulting from work stress, interventions at the workplace will require extended follow-up times in order to observe this reversal. Fortunately, innovative ways of measuring changes in psychosocial stressors at work or evaluation of more intermediate physiological outcomes, such as changes in blood pressure, cortisol, or other markers of cardiovascular strain, can be utilized.[169] On the other hand, legislation has already successfully produced societal-level changes in many European countries by limiting exposure to psychosocial stressors for many workers. Such legislation in other countries, including the United States, might reduce the need for many local intervention studies and suggests the utility of cross-country comparison studies.[170]

Fourth, working people are usually the most knowledgeable about the existence of unhealthy working conditions. Thus, the participation of workers in all aspects of research and in designing and implementing organizational change is crucial to the conduct of feasible and successful intervention programs. Employee participation in workplace interventions has a further benefit in that participation in change can lead to increases in healthy job characteristics such as job control and social support while moderating job demands, thus improving employee health and making organizations "healthier."[171–173] Additionally, recent research evidence supports the conclusion that when organizations include working people in the process of organizational change and

when they introduce organizational-level changes in concert with health promotion (behavioral change programs), efforts to change health behaviours are more likely to be effective.[174–178] There are numerous potentially beneficial approaches to worker participation, including involvement of labor unions in improving working conditions, labor-management partnerships, worker cooperatives, and researcher-worker collaborations, such as participatory action research, all of which need to be conducted and evaluated.[178–181]

Policy Considerations

The chronic disease epidemics associated with globalization are increasing at a dramatic pace, and in the United States there have been continued marked increases in the incidence and prevalence of hypertension, obesity, and diabetes. The post-World War II decline in CVD mortality rates in the United States has slowed or stopped in prime working-age populations (ages 35–54).[182] Recent research findings suggest that some of the increases in CVD risk factors are a likely consequence of the increasing demands at the workplace and the precipitous rise in precarious employment arrangements characterized by a rise in involuntary part-time work, short-term contracts, and independent contractors, which lack benefits, employment security, or workplace protections. If these trends of deteriorating working conditions continue unabated, the epidemics of social and work-related chronic diseases may continue to increase as well and further impact the quality of life and health of working people.

The Costs of Work Stress: Medical and Economic

While CVD is responsible for 30% of all deaths worldwide, 80% of the burden of CVD deaths now occurs in developing countries.[20] Medically treating 1.5 billion people with hypertension and CVD, given current economic and health care systems, is not feasible; alternative solutions are necessary and possible. Medical treatment of CVD risk factors, such as hypertension and cholesterol, with medication, while generally beneficial, represents a costly monetary approach to controlling these epidemics. Already 1 in 6 U.S. health dollars are spent on CVD and U.S. health care costs for CVD are predicted to increase to $818 billion by 2030.[183] Costs of treating CVD are still high even in the national health care systems of many European Union countries (EU €169 billion/year).[184]

Medical treatment of hypertension with anti-hypertensive medications also have limitations in their efficacy of treatment and documented side effects.[185] For example, a recent Cochrane review found that there is limited benefit from the treatment of individuals with mild hypertension (individuals with systolic blood pressure 140–159 mmHg and diastolic blood pressure 90–99 mmHg).[185] This review also concluded that there is a failure to demonstrate benefit from

treatment and that about 9% of the clinical trial participants withdrew due to side effects of medications.[184] Evidence also exists of a possible J-shaped curve of benefit suggesting that there is an optimal target level of treated BP and that more aggressive lowering of BP may result in increases in mortality or morbidity.[186] Although the recent SPRINT trial has suggested there may be some benefit to aggressive treatments, there is controversy over its findings, including side effects.[187]

Workers with chronic illnesses are expensive to care for and work at a reduced level (presenteeism) or frequently miss time from work due to their illnesses or the side effects of their treatments, manifested by increased sick leave, absenteeism, disability, and worker's compensation payments. A relationship between psychosocial work factors and these outcomes has been demonstrated.[87,188–191] Unhealthy working conditions, as contributors to these illnesses, also have economic costs in the hundreds of billions of dollars in the United States.[192] Researchers at Harvard and Stanford recently published an estimation of health care costs associated with 10 workplace stress exposures, including job demands, job control, job insecurity, low social support at work, long work hours, and shift work, as well as unemployment and lack of health insurance.[193] More than 120,000 U.S. deaths each year and 5%–8% of health care costs were conservatively estimated to be attributable to workplace stress exposures.[193] With U.S. health care costs reaching $3 trillion in 2014,[194] 6% of these costs represent $180 billion.

Integrating Workplace Health Promotion and Work Organization Change

The National Academies Institute of Medicine recommends a strategy for reducing cardiovascular disease by reducing risk factors and managing disease.[6] The strategy incorporates multiple intervention strategies across sectors, integrating health promotion, prevention, and disease management. In particular, societal or community-level public health policy interventions such as tobacco control (e.g., taxation of cigarette smoking, smoke-free environments) and reduction in salt consumption/use in food show some evidence of reducing CVD risk (pp. 197–202).[6,195]

On the other hand, workplace health promotion aimed at reducing individual risk and unhealthy behaviors such as smoking, overeating, and lack of exercise has met with limited effectiveness.[196–199] One limitation identified in these approaches is a failure to address the work environment as a source of stress leading to CVD or CVD risk. The National Institute for Occupational Safety and Health recommends in its Total Worker Health approach, an integrated approach to reducing health risks that includes health promotion and disease management aimed at individuals, but also involves changing the work environment and creating a culture of health.[200]

Work stressors and their health consequences are not wholly preventable or treatable by solely taking an individual or medical approach. While many researchers, practitioners, and policy makers tend to focus on individual behavioral changes to reduce the risk of CVD and the medical control of CVD risk factors such as hypertension and cholesterol, this focus does not preclude broader public health and work organizational changes. Responsibility for health should be a shared social and societal goal, taking into account "upstream" or social causes of ill health rather than leaving the responsibility to overburdened individuals and families. Democratic societies have elected to allocate resources to protect the public's health, including the health and safety of working people. The cost of "externalities" of doing business, including impacts on the work environment and on the health of working people from business activities, or to the patient from unexpected side effects of medical care are, unfortunately, all too frequently left out of the equation when deciding on the proper course of action. Corporate decision makers are frequently unwilling or unable to look beyond short-term interests or business cycles to the long-term costs to society and business—costs that will continue to mount if not recognized and acted upon.

National Legislative Change and International Models

The workplace, government, and the courts are the major institutions where struggles are carried on between management and labor for control over work processes. These struggles have resulted, in some cases, in improved working conditions and in limitations to the intensification of work in the global economy, suggesting that work organization can be changed to create healthier working conditions.[99,100,120,201–208] However, workers in many nations face weaker bargaining positions with regard to employers as the processes of globalization have shifted power and wealth to those at the top. Unlike labor, global capital faces no national boundaries, providing capital with a profound advantage over labor as evidenced by declining union density, particularly in the United States.[112] The U.S. labor movement has been largely unsuccessful in enacting legislation to improve psychosocial working conditions as was achieved in the Scandinavian countries,[209,210] with the exception of some state laws, such as those banning mandatory overtime or mandating staffing levels for nurses.[211]

Since the 1970s, in Northern and Western Europe, there has been a concerted effort to reduce and prevent workplace psychosocial stressors (e.g., the Swedish Work Environment Act, Act No. 677, amended in 1991, and EU-OSHA Framework Directive)[212] and, arguably, that may account for the lower prevalence of job strain and other job stressors in some European countries.[213] In addition, despite the impact of the global recession on European labor markets, working conditions in Western Europe continue to be better than in most other countries and Western Europe remains a model for other advanced

industrialized nations, particularly due to higher union density and the laws and regulations limiting exposure to workplace stressors.[14,88,214,215] Additionally, anti-hierarchical management models, which are widespread in Scandinavian countries, encourage greater participation and delegation of responsibility to autonomous employee teams and lead to more employee engagement and innovation.[216]

The World Health Organization's "Healthy Workplaces" extended the European framework to a global framework for business and community stakeholders.[25] In the United States, the National Institute for Occupational Safety and Health's Total Worker Health™ approach, while not as broad-reaching as the European initiatives, is based on evidence for the effectiveness of behavioral change (such as smoking cessation) when accompanied by occupational health and safety changes and makes the business case for organizational change. The evidence base for the effectiveness of work organization interventions is growing, but more evidence is needed on the synergy inherent in the Total Worker Health approach.[99,100,177,202,217,218]

When assessing public health strategies for the prevention of chronic disease in general and CVD in particular, the evidence needs to be fully considered regarding the importance of work organization in contributing to CVD and other chronic diseases, as well as the European legislative approaches that may be successfully reducing work organization stressors.

Conclusions

The existing evidence and a moral commitment to creating a "healthy society" is sufficient to justify the following policy steps: implementing national surveillance of occupations, industries, and workplaces to identify elevated levels of hazardous work characteristics; passage of regulations and laws limiting psychosocial stressors at the workplace; establishing upper limits of weekly and yearly work hours (to reduce CVD risk); mandating vacation time for all workers to facilitate recovery; passing regulations to mandate a "living wage" that provide sufficient support so that workers are not forced to work excessively long hours; and passing legislation that increases the economic security of precarious workers.

Our efforts to prevent CVD, as social epidemiologists and occupational health researchers, should include collaboration with all those committed to improve working conditions. An important first step is to educate professionals and the public that improving working conditions and worker health is a key part of preventing CVD and CVD risk epidemics, as well as improving the quality of life of working people. Given the high costs of medical treatment and the economic costs to employers and society of ill health, lost productivity, and sickness absence, it is in the interest of all to seriously consider improving work organization. If there is a silver lining to our findings that working

conditions play an important role in the etiology of CVD, it is that preventing these outcomes will require creating healthier workplaces and healthier jobs for all working people, with the dual consequences of improved well-being and a reduced burden of chronic disease later in life.

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Author Biographies

Peter L. Schnall is clinical professor of medicine at the Center for Occupational and Environmental Health at the University of California, Irvine where he directs the program in work organization and cardiovascular disease. He is a recognized expert on the role of occupational stress in contributing to hypertension and cardiovascular disease. His research includes designing and directing the New York City Work Site Ambulatory Blood Pressure Study (conducted 1984–2001) which demonstrated a significant association between psychosocial work stress and ambulatory blood pressure and increased cardiac left ventricular mass. He has studied the impact of psychosocial stressors on CVD risk factors including blood pressure and obesity for more than 30 years. Dr Schnall was the editor of the first textbook on work and cardiovascular disease titled "The Workplace and Cardiovascular Disease" (Hanley & Belfus, 2000), as well as the lead editor of a textbook on job stress and health titled "Unhealthy Work" (Baywood 2009). He is a member of the ICOH Scientific Committees—Work Organizational and Psychosocial Stress as well as

Cardiology in Occupational Health. Dr Schnall was awarded the Jean Spencer Felton Award for Excellence in Scientific Writing, awarded by the Western Occupational and Environmental Medical Association in 2012.

Marnie Dobson, PhD, is an adjunct assistant professor at the Center for Occupational and Environmental Health, University of California, Irvine, and the Associate Director of the Center for Social Epidemiology. She is a medical sociologist specializing in work stress research in occupational health, particularly work organization, CVD, obesity and mental health with several blue collar populations including firefighters, communications technicians and urban transit operators. Her expertise in qualitative methods have significantly enhanced the findings regarding work organizational hazards in the etiology of obesity (see Dobson et al., AJIM 2013). Her expertise in qualitative research has also led to the inclusion of a participatory action research approach to traditional epidemiological survey studies in these populations, which has fostered collaborative processes with "subjects of the research" who became primary contributors to the research process, as well as encouraging ongoing relationships with key stakeholders, an essential component of successful intervention development. In addition to her work as co-investigator on grants investigating occupational stressors and obesity, she was co-editor and contributing author of the book *Unhealthy Work: Causes, Consequences, and Cures* published by Baywood.

Paul Landsbergis is associate professor in the Department of Environmental and Occupational Health Sciences, State University of New York-Downstate School of Public Health in Brooklyn, New York. He conducts research and teaches on work organization, work stress, occupational health inequalities, socioeconomic position, hypertension, cardiovascular disease, psychological disorders and musculoskeletal disorders. He has studied health and safety risks of hazards in various occupations, including bus and subway operators, locomotive engineers, railroad maintenance workers, teachers, nurses, social service workers, autoworkers, parole officers, sanitation workers, mailhandlers, restaurant workers and World Trade Center rescue and recovery workers. Dr Landsbergis co-edited the first textbook on "The Workplace and Cardiovascular Disease" (Hanley & Belfus, 2000), and a textbook on job stress and health ("Unhealthy Work", Baywood, 2009). He is Deputy Editor of the American Journal of Industrial Medicine, and on the Editorial Board of New Solutions. Dr Landsbergis is a member of the International Commission on Occupational Health Scientific Committee on Cardiology in Occupational Health and a Fellow of the U.S. Academy on Workplace Bullying, Mobbing and Abuse. He was previously a member of the NIOSH NORA Intervention Effectiveness Research Team, and the National Research Council's Committee on the Health and Safety Needs of Older Workers.