WORK HOURS, MUSCULOSKELETAL DISORDERS AND CVD RISK

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FINAL REPORT

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LIST OF ABBREVIATIONS

ABP	ambulatory blood pressure
ACGME	Accreditation Council for Graduate Medical Education
BMI	body mass index
BP	blood pressure
CESDR	Center for Epidemiologic Studies Depression Scale Revised
CVD	cardiovascular disease
DBP	diastolic blood pressure
DHEA	dehydroepi-androsterone sulfate
ERI	effort-reward imbalance
HTN	hypertension
hx	history of disease
IT	intervention team
JCQ	**Job Content Questionnaire**
LPN	licensed practical nurse
MSD	musculoskeletal disorders
PAR	participatory action research
QES	Quality of Employment Surveys
RN	registered nurse
SBP	systolic blood pressure
SEIU	Service Employees International Union
SES	socioeconomic status
WSBPS	Work Site Blood Pressure Study

ABSTRACT

This research program, which included four studies, was designed to examine the impact of long work hours and other job stressors on blood pressure (BP), cardiovascular disease (CVD) risk, and musculoskeletal disorders (MSDs). CVD is the number one cause of illness and death in the U.S., and high blood pressure is a common and powerful risk factor for CVD. Work-related MSDs, such as low back pain, tendinitis, and carpal tunnel syndrome, account for a large proportion of the cost of work-related illness in the U.S.

The first study involved analyses of medical claims filed by unionized hospital workers in New York City to a joint union-management self-insured fund. In the three other studies, 431 hospital workers and 27 home health care workers from New York City completed questionnaires and 276 had their BP measured while working using ambulatory (portable) blood pressure (ABP) monitors, the gold standard in BP measurement. Nurses and nurses' aides participated in the study at Hospital A, while lower status employees participated at Hospital B.

Among employees at Hospitals A and B, there was no association between ABP and usual work hours or work hours in the month before ABP measurement. However, data from the medical insurance claim database revealed that registered nurses (RNs) working more than 40 hours per week (averaged over the previous 3 months) were nearly three times more likely to file a medical claim for hypertension (high blood pressure) than RNs working 31-40 hours per week.

At Hospital B, in 2000, female nurses and nurses' aides working 12-hour shifts had much higher ABP at work, home and during sleep than those working 8-hour shifts, adjusting for age, race, and other risk factors for high BP. ABP differences between shifts were 4-19 mm Hg systolic and 3-8 mm Hg diastolic. However, this effect was not seen in 1995.

At Hospital A, evening, night and rotating shiftworkers had higher ABP than day workers when controlling for age, race, and gender (6.3 mm Hg systolic, 4.5 mm Hg diastolic), but this effect was smaller when controlling for other risk factors for high BP. At Hospital B, compared to day shift nurses and aides, evening shift workers (4 pm-midnight) had higher ABP at work (0-4.3 mm Hg systolic, -1.3-2.7 mm Hg diastolic), home (1.1-15.6 mm Hg systolic, 2.0-6.2 mm Hg diastolic), and sleep (4.1-9.5 mm Hg systolic, 1.7-6.3 mm Hg diastolic) in both 1995 and 2000.

At Hospital A, among women, those with high demand-low control work ("job strain") or high efforts combined with low rewards at work had higher ABP (4.8-6.6 mm Hg systolic and 3.2-4.3 mm Hg diastolic) than those with job strain or effort-reward imbalance.

There was some suggestion, although not consistent, of interactions between work hours and other stressors. At Hospital B, overtime worked in the past month was associated with higher work ABP, but only for employees with job strain. At Hospital A, ABP was higher in employees working overtime but only in the group with only a high school education.

Occult hypertension means normal office BP (<140/90), but high workday ambulatory BP. In Hospital A, occult hypertension was seen in 16-23% of men and 19-20% of women with normal office BP. Occult hypertension was more common in shiftworkers but not among those

working long hours. There was some suggestion of higher risk of occult hypertension among workers facing job strain or high efforts combined with low rewards.

Some research has found that depression, anxiety, short sleep hours and fatigue are risk factors for future heart disease. At Hospital A, employees working more than 40 hours per week had higher levels of fatigue, but not more symptoms of anxiety or insomnia. Employees with paid work plus home tasks totaling more than 57.5 hours per week were more than four times more likely to report symptoms of depression (but not fatigue, insomnia or anxiety). Employees facing job strain or high efforts combined with low rewards at work were also more likely to report more symptoms of depression, anxiety, insomnia and fatigue.

Hospital service and maintenance workers and licensed practical nurses/nurses' aides (jobs with substantial ergonomic risk factors) were nearly two times as likely to file a medical claims for a low back musculoskeletal disorder (MSD) than paraprofessional hospital workers such as social worker, physicians' assistant, emergency medical technician or pharmacist. Male hospital workers working more than 50 hours per week (averaged over the previous 3 months) were 50% more likely to file a medical claim for a low back MSD, and those working 46 or more hours per week were more than four times more likely to file a medical claim for wrist/hand MSDs. However, women working more than 50 hours per week were only half as likely to file a medical claim for a neck MSD. Work hours were not related to shoulder MSDs. In case-control analyses among a subset of participants who completed the study questionnaire, neither work hours in the 1-3 month nor the 4-6 month periods prior to filing a medical claim were significantly associated with claims for MSDs.

The results of these studies suggest that programs and policies to reduce employees' exposure to work stressors, including long weekly work hours, 12-hour shifts, evening shifts, high demand-low control work and high efforts combined with low rewards at work, can be implemented in order to reduce the chance that employees will develop high BP, heart disease, stroke, and work-related MSDs. Employer programs and policies need to carefully evaluated for their health effects. Various programs and policies have been recommended by researchers and government agencies (such as NIOSH) including: worksite surveillance (periodic surveys and medical exams, screening for occult hypertension, and analyses of existing medical claim databases); integration of health promotion (programs for exercise, healthy diet and smoking cessation) with occupational health approaches (reducing sources of stress in the workplace), and job redesign (for example, increasing employee participation and control and increasing work rewards, which include respect, support, income, promotion prospects and job security).

HIGHLIGHTS/SIGNIFICANT FINDINGS

AIM 1) To determine the associations between extended work hours, ergonomic risk factors, psychosocial job stressors, and low back and upper extremity musculoskeletal disorders in the study population (STUDIES #1 AND 2).

Hospital service and maintenance workers and licensed practical nurses/nurses' aides (jobs with substantial ergonomic risk factors) were nearly two times as likely to file a medical claims for a low back musculoskeletal disorder (MSD) than paraprofessional hospital workers such as social worker, physicians' assistant, emergency medical technician or pharmacist. Male hospital workers working more than 50 hours per week (averaged over the previous 3 months) were 50% more likely to file a medical claim for a low back MSD, and those working 46 or more hours per week were more than four times more likely to file a medical claim for wrist/hand MSDs. However, women working more than 50 hours per week were only half as likely to file a medical claim for a neck MSD. Work hours were not related to shoulder MSDs.

In case-control analyses among a subset of participants who completed the study questionnaire, neither work hours in the 1-3 month nor the 4-6 month periods prior to filing a medical claim were significantly associated with claims for MSDs.

AIM 2) To determine the associations between extended work hours, psychosocial job stressors (including job strain and effort-reward imbalance), blood pressure elevation and CVD risk in the study population (STUDIES #1, 3 AND 4).

Long work hours during the months preceding ambulatory blood pressure (ABP) measurement

Among employees at Hospitals A and B, there was no association between ABP and usual work hours or work hours in the month before ABP measurement. However, data from a medical insurance claim database revealed that registered nurses (RNs) working more than 40 hours per week (averaged over the previous 3 months) were nearly three times more likely to file a medical claim for hypertension (high blood pressure) than RNs working 31-40 hours per week.

Long work hours on the day of ambulatory blood pressure (ABP) measurement

At Hospital B, in 2000, female nurses and nurses' aides working 12-hour shifts had much higher ABP at work, home and during sleep than those working 8-hour shifts, adjusting for age, race, and other risk factors for high BP. ABP differences between shifts were 4-19 mm Hg systolic and 3-8 mm Hg diastolic. However, this effect was not seen in 1995.

Shiftwork

At Hospital A, evening, night and rotating shiftworkers had higher ABP than day workers when controlling for age, race, and gender (6.3 mm Hg systolic, 4.5 mm Hg diastolic), but this effect was smaller when controlling for other risk factors for high BP. Compared to day shift nurses and aides, Hospital B evening shift workers (4 pm-midnight) had higher ABP at work (0-4.3 mm Hg systolic, -1.3-2.7 mm Hg diastolic), home (1.1-15.6 mm Hg systolic, 2.0-6.2 mm Hg diastolic), and sleep (4.1-9.5 mm Hg systolic, 1.7-6.3 mm Hg diastolic) in both 1995 and 2000.

Other work stressors

At Hospital A, were lower status worked were enrolled in the study, among women workers, those with high demand-low control work ("job strain") or high efforts combined with low rewards at work had higher ABP (4.8-6.6 mm Hg systolic and 3.2-4.3 mm Hg diastolic) than those without job strain or effort-reward imbalance.

Interaction between long work hours and other work stressors

At Hospital B, each overtime hour worked per week (in the previous month) was associated with about 1 mm Hg higher systolic work and 0.2 mm Hg higher diastolic work ABP – but only for employees with job strain (high demand-low control work). For those not facing job strain, overtime work hours were associated with lower work ABP. While these significant interactions were intriguing, they were not seen in data from 1995, nor with sleep ABP, nor with work hours on the day of ABP measurement. At Hospital A, ABP was higher (8.7 mm Hg systolic, 5.3 mm Hg diastolic) in employees working more than 40 hours per week in the group with only a high school education, compared to no effect or even lower ABP when working more than 40 hours per week in employees with higher levels of education.

Occult (hidden) hypertension

Occult hypertension means normal office BP (<140/90), but high workday ABP. In Hospital A, occult hypertension was seen in 16-23% of men and 19-20% of women with normal office BP. Occult hypertension was more common in shiftworkers but not among those working long hours. There was some suggestion of higher risk of occult hypertension among workers facing job strain or high efforts combined with low rewards.

Psychological/psychosomatic distress

Some research has found that depression, anxiety, short sleep hours and fatigue can predict future heart disease. At Hospital A, employees working more than 40 hours per week had higher levels of fatigue, but not more symptoms of anxiety or insomnia. Employees with paid work plus home tasks totaling more than 57.5 hours per week were more than four times more likely to report symptoms of depression (but not fatigue, insomnia or anxiety). Employees facing job strain or high efforts combined with low rewards at work were also more likely to report more symptoms of depression, anxiety, insomnia and fatigue.

TRANSLATION OF FINDINGS

Results of this study suggest that programs and policies to reduce employees' exposure to work stressors, including long weekly work hours, 12-hour shifts, evening shifts, high demand-low control work and high efforts combined with low rewards at work, can be implemented in order to reduce the chance that employees will develop high blood pressure, heart disease, stroke, and work-related musculoskeletal disorders. Employers' programs and policies need to be carefully evaluated for their health effects. Various programs and policies have been recommended by researchers and government agencies (such as NIOSH) including worksite surveillance, integration of health promotion with occupational health, and job redesign.

Worksite surveillance

Surveys can be periodically conducted (for example, once per year) that ask about working conditions, such as long work hours, shiftwork, job strain, and effort-reward imbalance, and symptoms of depression, anxiety, insomnia and fatigue. Changes in working conditions and symptoms of psychological strain reported over time can provide valuable information about the effects of efforts to improve the work environment. Periodic medical examinations of high-risk employees can also be conducted. For example, employees exposed to shiftwork, job strain, or effort-reward imbalance can receive annual ambulatory blood pressure (ABP) monitoring to determine whether they have occult (hidden) hypertension.

Health insurance fund databases can also be useful for surveillance for occupational diseases, particularly for diseases not typically considered work-related, such as heart disease or hypertension. However, to be more useful, medical claim databases need to be merged with company or union databases that contain detailed information about employee job title, work history, and perhaps work conditions.

Integration of health promotion with occupational health

Worksite health promotion, including efforts to promote exercise, healthy diet and smoking cessation, is an important component of programs to reduce high blood pressure and risk of heart disease. Unfortunately, lower status workers are less likely to participate in such programs, and often face greater job stressors. Programs that combine health promotion with efforts to reduce hazards and sources of stress at work (integrated programs) appear to be effective at reaching lower status workers. Integrated health promotion-occupational health programs have shown positive results in studies in Massachusetts and in the Netherlands.

Job redesign

There are a variety of research studies that have examined the redesign of jobs to reduce job stress and create a more healthy work organization. Examples include increasing worker participation and employee control (to reduce job strain), making overtime voluntary rather than mandatory (another way of increasing employee control and reducing the amount of overtime worked), adequate staffing (to reduce the need for overtime hours), and increasing rewards at work for employees facing high efforts plus low rewards. The "rewards" measured in the current study (and in other studies of effort-reward imbalance) include respect, support, income, promotion prospects and job security.

OUTCOMES/RELEVANCE/IMPACT

This was the first study of long work hours and blood pressure (BP) among women workers, and the first to test the interaction between work hours and socioeconomic status on BP. This was only the second study to examine work environment factors that predict occult (hidden) hypertension (high BP while working but normal BP in the doctor's office). Occult hypertension has rarely been studied, but is of major clinical significance. Because people with occult hypertension have an increased risk of developing heart disease compared to people with normal BP, they need counseling, possibly treatment, and assessment of sources of stress on their jobs. However, they rarely receive these because their office BP seems normal.

In the current study, BP was measured by ambulatory (ABP) monitoring, currently considered the "gold standard" of BP measurement. ABP monitoring produces more reliable and valid measures of a person's true BP than single measurements using a standard sphygmomanometer in a doctor's office.

Employers' administrative databases can provide objective information for research studies on past work hours (for hourly workers). Health insurance fund databases can provide large numbers of medical claims that allow us to conduct surveillance for occupational diseases, particularly for diseases not typically considered work-related, such as cardiovascular disease. Surveillance would be greatly improved by efforts to combine medical claim datasets with company or union datasets that contain detailed information about employees' job title, work history, and perhaps working conditions.

These study results need to be repeated in larger groups of employees (to provide greater statistical power), in employees outside the health care industry (to be able to generalize results to a broader workforce), and in employees working longer hours than those in current study.

SCIENTIFIC REPORT

See four attached study reports containing detailed information on the methods, results and conclusions of each of the four studies funded by this grant.

PUBLICATIONS

Refereed journal articles (2)

Landsbergis PA: [2003] The changing organization of work and the safety and health of working people. Journal of Occupational and Environmental Medicine 45(1):61-72.

The NIOSH NORA Organization of Work team commissioned this review paper on the changing organization of work, including long work hours, based upon the PI's reputation as an expert in this field. The article contains a review of NIOSH's publication "The Changing Organization of Work and the Safety and Health of Working People" (Publication No. 2002-116) and a detailed commentary on recent changes in the organization of work and their health effects.

Landsbergis P: [2004] Long work hours, hypertension, and cardiovascular disease. Cadernos Saúde Pública 20(6):1746-1748.

This review of studies of long work hours, hypertension, and cardiovascular disease was an update of the literature review provided in the grant proposal. It was invited by the editors of this journal based upon the PI's reputation as an expert in this field, and his work with Brazilian shiftwork and work hour researchers with whom the PI is a colleague and co-author.

Conference presentations (14)

Janevic T, **Landsbergis PA.** [2002] Job stress, hypertension and cardiovascular disease risk among autoworkers (poster). American Public Health Association, Philadelphia, PA, November 12

Janevic T, **Landsbergis PA.** [2003] Job stress, hypertension and cardiovascular disease risk among autoworkers. APA-NIOSH Conference on Work, Stress and Health, Toronto, Ontario, March 21

Gurnitz KL, **Landsbergis PA**, Dropkin J, Herbert R. [2003] Extended work hours, work stressors, cardiovascular disease and musculoskeletal disorders among health care workers. APA-NIOSH Conference on Work, Stress and Health, Toronto, Ontario, March 21

Gurnitz KL, **Landsbergis PA,** Dropkin J, Herbert R. [2003] Extended work hours, cardiovascular disease and musculoskeletal disorders among health care workers (poster). American Public Health Association, San Francisco, California, November 17

Gurnitz KL, **Landsbergis PA,** Dropkin J, Herbert R. [2004] Extended work hours, cardiovascular disease, and musculoskeletal disorders among health care workers (poster). Long Working Hours, Safety, and Health: Towards a National Research Agenda. University of Maryland, Baltimore, MD, April 29

Paik J, **Landsbergis PA,** Gurnitz KL, Schnall P, Pickering T, Schwartz J. [2004] The association of overtime work hours with ambulatory blood pressure in a cohort of female nurses (poster).

Long Working Hours, Safety, and Health: Towards a National Research Agenda. University of Maryland, Baltimore, MD, April 29

Landsbergis PA. [2004] Work organization, job stress and health promotion. NIOSH Conference on Steps to a Healthier US Workforce 2004: Integrating Protection and Promotion, Washington, DC, October 28

Landsbergis PA, Travis A, Schnall PL, Jauregui M. [2006] Job Stressors and ambulatory blood pressure among health care workers. APA/NIOSH Conference on Work, Stress and Health 2006, Miami, FL, March 2

Paik J, **Landsbergis PA**, Gurnitz KL, Schnall P, Pickering T, Schwartz J. [2006] The association of overtime work hours with ambulatory blood pressure in a cohort of female nurses. NIOSH NORA Symposium 2006, Washington, DC, April 18

Landsbergis PA. [2006] Work organization, stress, the changing nature of work, and cardiovascular disease (keynote address). Partnership for a Heart Healthy Stroke Free Massachusetts, Worcester, MA, June 2

Landsbergis PA, Travis A, Schnall PL, Jauregui M. [2006] Job Stressors and ambulatory blood pressure among health care workers. International Congress of Occupational Health, Milan, Italy, June 12

Landsbergis PA, Schnall P, Dobson M, Baker D, Belkic K. [2006] Evidence for the relationship between job strain, hypertension and CVD. Cardiovascular Diseases and Work (ICOH 2006 symposium), Varese, Italy, June 17

Landsbergis PA. [2006] Organization of work, stress, the changing nature of work and cardiovascular disease. ABERGO 2006, Curitiba, Brazil, October 30

Landsbergis PA. [2006] Organization of work, stress, the changing nature of work and cardiovascular disease. Fiocruz Research Institute, Rio de Janeiro, Brazil, October 31

INCLUSION OF GENDER AND MINORITY STUDY SUBJECTS

See attached Enrollment Inclusion Reports, the first for analysis of existing medical claim data, which involved no additional data collection from individuals (STUDY #1); the second for studies which involved data collection from individuals (STUDIES #2, 3, 4). Data on race and ethnicity were not available in STUDY #1. In addition, STUDY #1 contained six overlapping but not identical medical claim databases. Data on gender is included in the Enrollment Inclusion Report from the largest of the six databases (hypertension).

INCLUSION OF CHILDREN

All study participants were 21 years or age or older since the study eligible criteria were employment as a hospital worker or home health care worker in New York City.

MATERIALS AVAILABLE FOR OTHER INVESTIGATORS

The questionnaires developed for the study, as well as the protocols for ambulatory and wrist blood pressure measurement monitoring in the workplace have been shared with several other researchers, and are available upon request to the Principal Investigator

Principal Investigator/Program Director (Last, First, Middle): Landsbergis, Paul A

Inclusion Enrollment Report

This report format should NOT be used for data collection from study participants.

Study Title: WORK HOURS, MUSCULOSKELETAL DISORDERS AND CVD RISK

Total Enrollment: ______ **Protocol Number:** STUDY #1 (largest of 6 databases)

Grant Number: R01 OH 07577

PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race				
	Sex/Gender			
Ethnic Category	**Females**	**Males**	**Unknown or Not Reported**	**Total**
Hispanic or Latino				**
Not Hispanic or Latino				
Unknown (individuals not reporting ethnicity)	8427	3569	0	11996
Ethnic Category: Total of All Subjects*	8427	3569	0	11996 *
Racial Categories				
American Indian/Alaska Native				
Asian				
Native Hawaiian or Other Pacific Islander				
Black or African American				
White				
More Than One Race				
Unknown or Not Reported	8427	3569	0	11996
Racial Categories: Total of All Subjects*	8427	3569	0	11996 *

PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)				
Racial Categories	**Females**	**Males**	**Unknown or Not Reported**	**Total**
American Indian or Alaska Native				
Asian				
Native Hawaiian or Other Pacific Islander				
Black or African American				
White				
More Than One Race				
Unknown or Not Reported	8427	3569	0	11996
Racial Categories: Total of Hispanics or Latinos**	8427	3569	0	11996 **

* These totals must agree.
** These totals must agree.

Inclusion Enrollment Report

This report format should NOT be used for data collection from study participants.

Study Title: WORK HOURS, MUSCULOSKELETAL DISORDERS AND CVD RISK

Total Enrollment: ________ **Protocol Number:** STUDIES #2, 3, 4

Grant Number: R01 OH 07577

PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race

	Sex/Gender			
Ethnic Category	**Females**	**Males**	**Unknown or Not Reported**	**Total**
Hispanic or Latino	59	23	0	82 **
Not Hispanic or Latino	292	52	0	344
Unknown (individuals not reporting ethnicity)	21	11	0	32
Ethnic Category: Total of All Subjects*	372	86	0	458 *
Racial Categories				
American Indian/Alaska Native	0	0	0	0
Asian	30	6	0	36
Native Hawaiian or Other Pacific Islander	0	0	0	0
Black or African American	172	36	0	208
White	90	10	0	100
More Than One Race	0	0	0	0
Unknown or Not Reported	80	34	0	114
Racial Categories: Total of All Subjects*	372	86	0	458 *

PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)

Racial Categories	**Females**	**Males**	**Unknown or Not Reported**	**Total**
American Indian or Alaska Native				
Asian				
Native Hawaiian or Other Pacific Islander				
Black or African American				
White				
More Than One Race				
Unknown or Not Reported	59	23	0	82
Racial Categories: Total of Hispanics or Latinos**	59	23	0	82 **

* These totals must agree.
** These totals must agree.

STUDY #1

EXTENDED WORK HOURS, CARDIOVASCULAR DISEASE AND MUSCULOSKELETAL DISORDERS AMONG HEALTH CARE WORKERS: AN ANALYSIS OF MEDICAL INSURANCE CLAIM DATA

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ABSTRACT

This study was designed to examine associations between work hours, socioeconomic status and work exposures (measured by job category), and incident medical claims from unionized health care workers in the New York City metropolitan area to a joint union-management self-administered and self-insured fund. Incident cases were the first claim within each of six musculoskeletal disorder (MSD) and cardiovascular disease (CVD) disease categories, without a previous MSD or CVD claim in the prior six months. Controls were all claimants with conditions not presumed to have extended work hours or work stressors as etiological factors and without an MSD or CVD claim in the prior 6 months. 4,857 incident cases and 13,083 incidence density matched controls had complete work hour data for three months before the medical claim. Associated were tested using unconditional logistic regression controlling for age.

Men working 46+ hours per week were at significantly increased risk for wrist/hand MSDs (OR = 4.58, 95% CI 1.04-20.21). Women working overtime were at significantly reduced risk of neck MSDs. Both women working fewer hours and men working >50 hours per week had a reduced risk of medical claims for hypertension. Service and maintenance workers (OR = 1.95, 95% CI 1.01-3.47) and LPNs/aides (OR = 1.95, 95% CI 1.11, 3.435) were at significantly increased risk of a low back MSD. However, despite some risk estimates substantially different from the null value, no associations were significant for other MSDs or CVD.

This study suggests the utility of using medical insurance claim databases to conduct occupational disease surveillance particularly for conditions not typically considered work-related, such as cardiovascular disease. Surveillance would be greatly enhanced by further efforts to combine medical claim datasets with demographic employees datasets that contain detailed information about job title, work history, and perhaps other work exposures.

INTRODUCTION

Associations have been observed between extended work hours and a variety of health outcomes (1-4), however, few studies have examined associations with musculoskeletal disorders (MSDs) or blood pressure (BP) elevation, a risk factor for cardiovascular disease (CVD). Two Japanese studies found evidence linking overtime work and BP among men working greater than 55 hours per week (5, 6). However, no association was observed between BP and work hours in male Korean engineers (52-89 hours per week in the past month) (7) and another Japanese study of male white-collar workers found an inverse association between hypertension and ≥10 (vs. <8) work hours per day (8). A recent study in California found that employees working more than 50 hours per week had a small increased risk of developing (self-reported) hypertension (OR=1.29, 95% CI: 1.10-1.52) compared to those working 11-39 hours/week (9).

Work hours were associated with hand/wrist MSDs among newspaper employees (10) and "extensive" overtime was associated with hand/arm discomfort among computer workers (11). However, overtime was not associated with records of lost-time hand/wrist MSDs among bank customer service workers (12). In Stockholm, overtime was a risk factor for low back pain for men only in combination with poor social relations (13). On the other hand, a substantial body of literature has linked increased levels of MSD symptoms and/or diagnoses with increased duration of exposure to physical risk factors over a work day (11, 14-16), in particular for computer workers (17-19), implying increased risk among workers facing overtime.

The current study was designed to examine associations between work hours, socioeconomic status and work exposures (both measured by a proxy variable, job category), and incident medical claims for CVD and low back, shoulder, neck and hand/wrist MSDs. Data was available from a joint union-management self-administered and self-insured fund, which includes medical claims from unionized health care workers in the New York City metropolitan area. Methods of analysis of existing medical claim databases for the purpose of occupational disease surveillance were originally developed by Park et al (20) and further developed by Landsbergis and Janevic for studies of autoworkers (21).

METHODS

The 1199SEIU National Benefit Fund (NBF) is a joint union-management self-insured fund that contains a computerized database with all medical, drug, hospital, disability and workers' compensation claims made by over 100,000 health care employees at all major New York City hospitals. The Fund covers about two-thirds of all 1199SEIU members in New York City (22). The database includes ICD9 codes and basic demographic data (age, gender, hours worked per month, and job category).

Data was available for analysis from 45,379 current employees at 23 hospitals, 45,005 of whom had work hour data available for the period July 1, 1998- June 30, 2001. 32,338 of these employees filed a total of 765,559 medical claims between January 1, 1999 and June 30, 2001.

Case and control definitions

Case and control definitions are listed in Table 1. ICD9 codes for MSD cases include those used in a study of occupational disease surveillance at an automotive factory (20). ICD9 codes for CVD cases are those commonly examined in studies of stress-related CVD conditions (23). ICD9 codes for controls include conditions that are not presumed to have extended work hours or work stressors as etiological factors, including osteoarthritis, dermatological conditions, congenital anomalies, benign gynecological conditions, and elective surgeries.

Table 1. Definitions of case and control conditions	
Musculoskeletal Disorders	**ICD9 Code**
Low Back	721.2-721.4X, 722.1X, 722.5X, 722.72, 722.73, 722.92, 722.93, 724.XX, 846.X, 847.2, 847.3, 847.4, 847.9
Neck	721.0, 721.1, 722.0. 722.4, 722.71, 722.91, 723.X, 847.0
Shoulder	715.11, 726.0, 726.1X, 726.2, 727.61
Wrist/Hand	443.0, 354.0, 354.1, 354.3, 715.14, 726.4, 727.01, 727.04, 727.05, 727.09, 727.4, 727.41, 727.42, 727.49
Cardiovascular Disease	
Hypertension	401-404.9
Heart Disease and Stroke	410-414.9, 430-438.9, 440-440.9
Controls	
Anemia	280-280-9
Congenital Anomalies	740-759.9
Dermatological Conditions	680-709.9
Ear Conditions	380-382.9
Elective Surgery	V50.00, V50.10, V50.20, V50.30, V50.90, V51.00
Genito-Urinary Conditions	580-629.9
Hepatitis	573-573.9
Hernia	550-550.9
Injuries	800-959.9
Neoplasms	140-239.9
Ocular Conditions	361-361.9, 365-365.03, 364.1-367.9
Pregnancy	650-651.9
Respiratory Conditions	460-519.9

Eligibility criteria

Incident cases were defined as the first claim within each of the six MSD and CVD disease categories, without a previous MSD or CVD claim in the prior six months. Controls were defined as all claimants with a control ICD9 code and without an MSD or CVD claim in the prior 6 months. To be eligible, all cases and controls also had to have at least three months of work hour data prior to date of medical claim available in the database.

Matching cases and controls

Controls were incidence-density-matched to cases by month of claim, that is, chosen at the same time as cases to allow for estimation of relations among incidence rates (24). One random control claim was chosen for each control member. Then, the ratio of control claims to case claims by disease category and month of claim was determined. We chose the smallest ratio of controls to cases for each disease category. Then, we randomly matched controls to cases using the following disease specific control/case ratios: 2.9 for low back, 7.5 for neck, 15.5 for shoulder, 20.4 for wrist/hand, 2.3 for hypertension and 8.7 for heart disease or stroke.

Work hour exposure

We identified hours worked per month during the three complete months before the medical claim. Hours worked during the month that the claim was filed was not included in analyses since it would be unknown whether overtime hours (if any) were worked before or after the claim was filed. This exclusion also reduces the potential bias of illness leading to fewer work hours. The number of MSD cases and controls with work hour and with job title data available for analysis is provided in Table 2. (Data for CVD cases available upon request.) Unfortunately, only about 17% of the sample had available job title information.

Table 2. Subject selection for analysis of MSDs

	Cases	Controls
Claimants	10,173	28,542
Claims	82,223	447,635
Incident Claims	6,930	
Did not file an MSD claim		15,625
Claimants with valid work hour data		
For 3 months prior to claim	4,857	13,083
With job title information	807	2,339

Job categories

The hospital workers union, 1199SEIU, created six job categories for their hospital-employed members for administrative purposes. These categories, in order of increasing status, are: service/maintenance, clerical, licensed practical nurse (LPN)/aide, technical, registered nurse (RN) and paraprofessional. See Table 3 for detailed job titles included in each category.

Table 3. Examples of job titles within each hospital employee job category	
Job category	**Examples of job titles**
Paraprofessional	social worker, physicians' assistant, perfusionist, emergency medical technician, pharmacist
Registered Nurse	registered nurse
Technical	operating room, laboratory, radiology, ultrasound, tomography, other diagnostic procedures technicians and technologists; rehabilitation, physical, occupation, recreational and speech pathologists or therapists
LPN/aide	Licensed Practical Nurse, certified nurse assistant, direct patient care worker having minimal credentials
Clerical	clerk, secretary, intake and discharge representative, accounts payable and receivable representative, unit head, administrative assistant, receptionist, telephone operator
Service/Maintenance	food service/preparation, housekeeper, janitor, groundskeeper, storekeeper, porter, painter, plumber, carpenter, electrician

Data analysis

The association between case-control status for each of the six diagnostic groups and gender, job category or weekly work hours was determined by unconditional logistic regression controlling for age. Analyses of job category also adjusted for gender and while analyses for weekly work hours stratified by gender. Analyses were conducted using SAS v. 6.1.

RESULTS

The demographics of each of the six health outcome datasets available for analysis were similar (Table 4). Approximately 70% of the samples were female, about 27% were at least 50 years of age, and about 20% had worked more than 40 hours per week during the month before the incident medical claim. About 7% had worked more than 50 hours per week. Job title data was only available for about 17% of the sample.

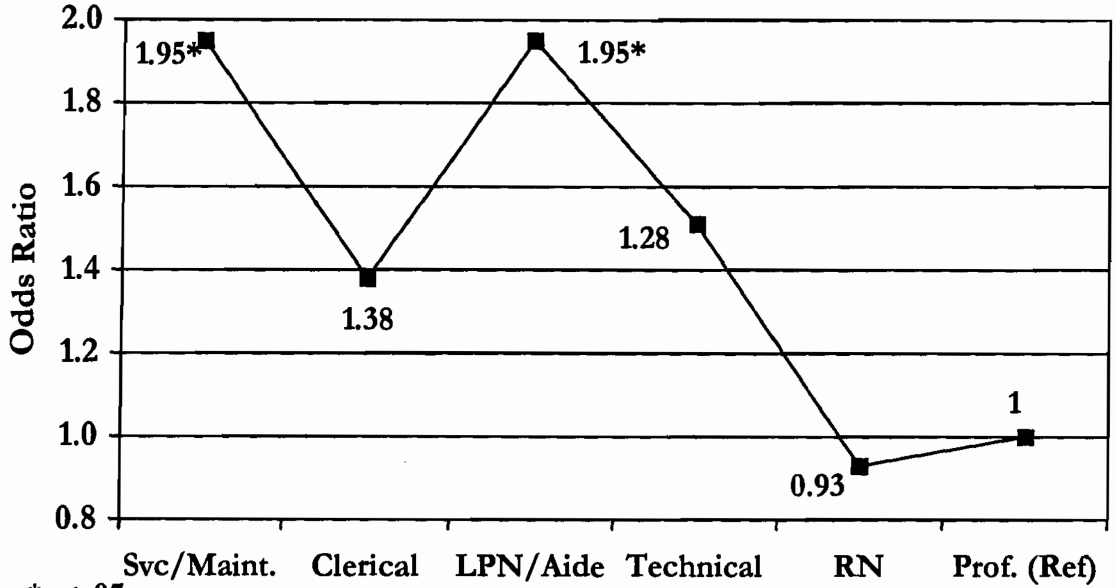
Women were at increased risk of filing a medical claim for wrist/hand MSDs, however, men were at increased risk of filing a claim for a low back MSD, hypertension or heart disease/stroke (Table 5). Service/maintenance workers (OR = 1.95, 95% CI 1.01-3.47) and LPNs/aides (OR = 1.95, 95% CI 1.11, 3.435) were at significantly increased risk of a low back

Table 4. Number of cases, controls and demographics in each health condition data set						
	Low Back	**Neck**	**Shoulder**	**Wrist/Hand**	**Hypertension**	**CVD**
N	11,020	9984	8063	8072	11,996	10,254
Female	7737 (70.2%)	7175 (71.9%)	5760 (71.4%)	5865 (72.7%)	8427 (70.3%)	7242 (70.6%)
Male	3283 (29.8%)	2808 (28.1%)	2303 (28.6%)	2207 (27.35)	3569 (29.8%)	3012 (29.4%)
Case	2828 (25.6%)	1180 (11.8%)	377 (4.7%)	472 (5.9%)	3595 (30.0%)	1058 (10.3%)
Control	8192 (74.3%)	8804 (88.2%)	7686 (95.3%)	7600 (94.2%)	8401 (70.0%)	9196 (89.7%)
Age: 18-49 yrs	8051 (73.1%)	7455 (74.7%)	6051 (75.1%)	6064 (75.1%)	8002 (66.7%)	7452 (72.7%)
50-59 yrs	2158 (19.6%)	1875 (18.8%)	1484 (18.4%)	1476 (18.3%)	2786 (23.2%)	2011 (19.6%)
60+ yrs	811 (7.4%)	654 (6.6%)	528 (6.6%)	532 (6.6%)	1208 (10.1%)	791 (7.7%)
Jobtitle data	1888 (17.1%)	1697 (17.0%)	1360 (16.9%)	1420 (17.6%)	2010 (16.8%)	1770 (17.3%)
***Hrs/wk: ≤40**	9021 (81.9%)	8166 (81.8%)	6585 (81.7%)	6658 (82.5%)	9894 (82.5%)	8347 (81.4%)
41-50	1296 (11.8%)	1145 (11.5%)	920 (11.4%)	896 (11.1%)	1307 (11.0%)	1221 (11.9%)
51+	703 (6.4%)	673 (6.7%)	558 (6.9%)	518 (6.4%)	795 (6.6%)	686 (6.7%)
* during 1 month before medical claim						

Table 5. Risk of MSD or CVD by gender, age-adjusted odds ratios, July 1999-June 2001			
	Female gender		
MSD	**OR**	**95% CI**	**p**
Low Back	.78	(0.71, 0.85)	<.0001
Neck	1.14	(0.99, 1.31)	.07
Shoulder	.79	(0.63, 0.99)	.04
Wrist/Hand	1.70	(1.34, 2.15)	<.0001
CVD			
Hypertension	.78	(0.71, 0.85)	<.0001
Heart Disease and Stroke	.70	(0.61, 0.81)	<.0001

MSD (Figure1). However, despite some risk estimates substantially different from the null value, no associations were significant for neck MSDs (Figure 2), shoulder MSDs (Figure 3), hand/wrist MSDs (Figure 4), hypertension (Figure 5) or heart disease/stroke (Figure 6), in part, due to the limited number of subjects with job title data.

Figure 1. Risk of Low Back MSD by Job Category
Age and gender-adjusted Odds Ratios, July 1999-June 2001



*p< .05

Figure 2. Risk of Neck MSD by Job Category
Age and gender-adjusted Odds Ratios, July 1999-June 2001

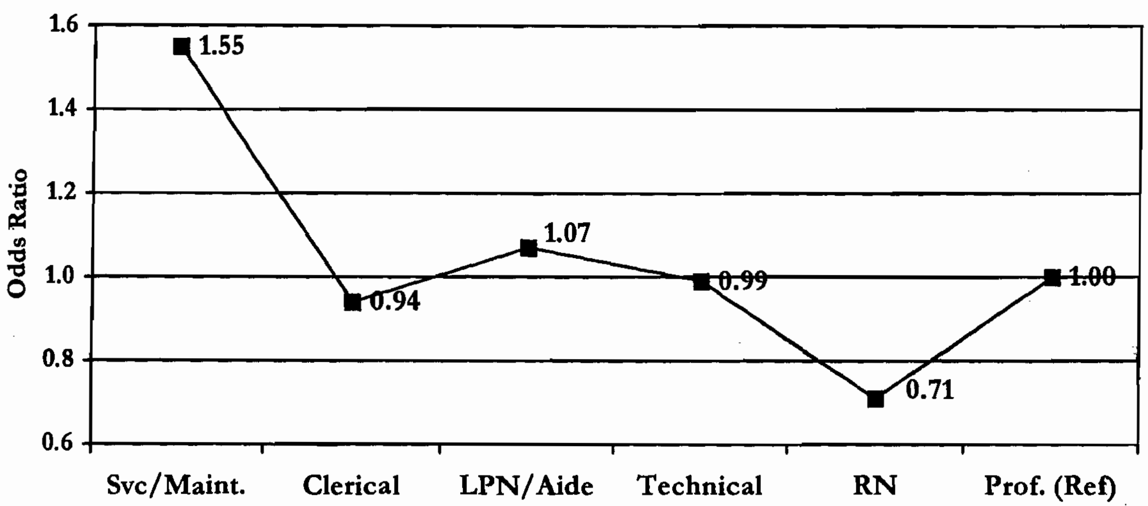


Figure 3. Risk of Shoulder MSD by Job Category
Age and gender-adjusted Odds Ratios, July 1999-June 2001

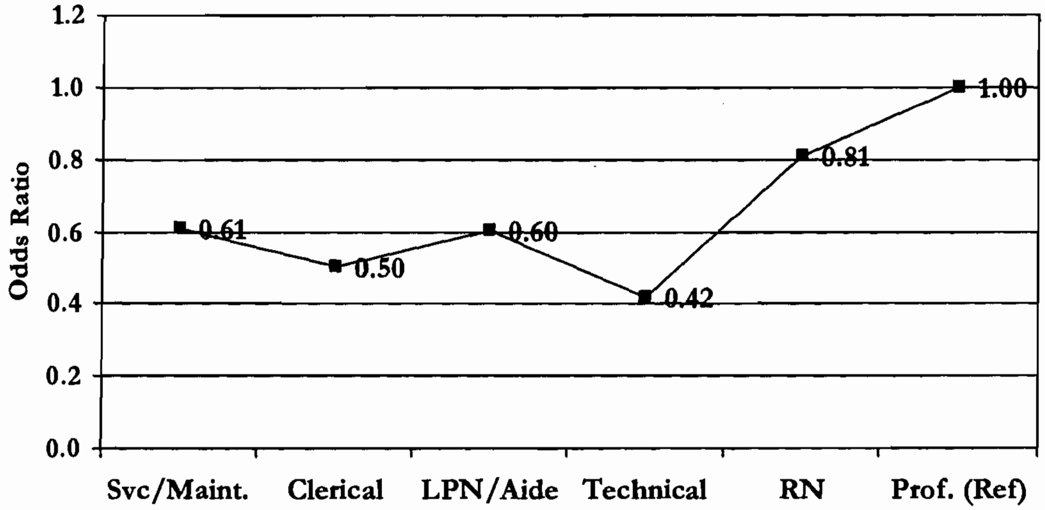


Figure 4. Risk of Wrist/Hand MSD by Job Category
Age and gender-adjusted Odds Ratios, July 1999-June 2001

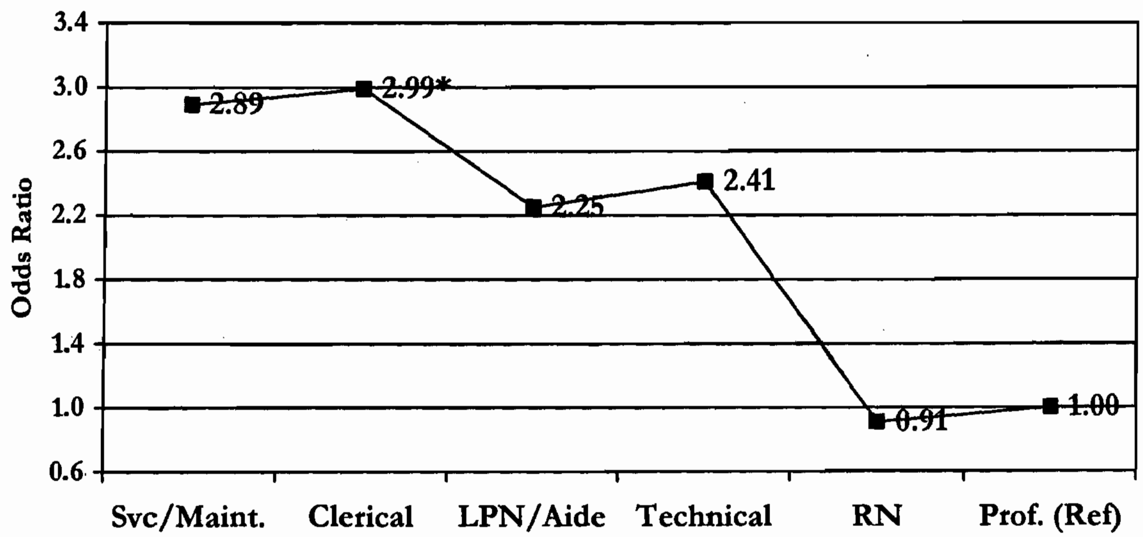


Figure 5. Risk of Hypertension by Job Category
Age and gender-adjusted Odds Ratios, July 1999-June 2001

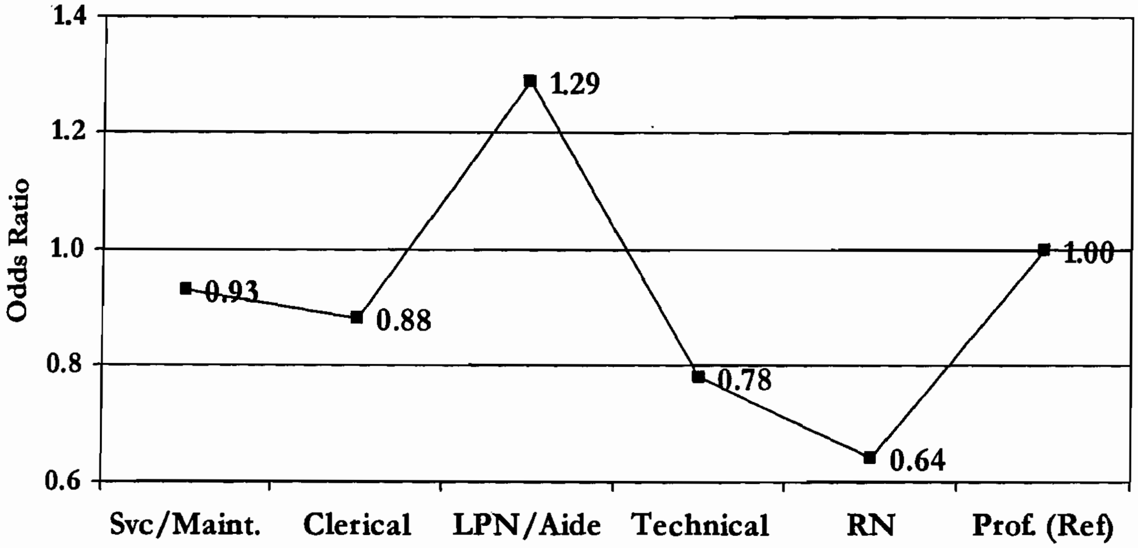
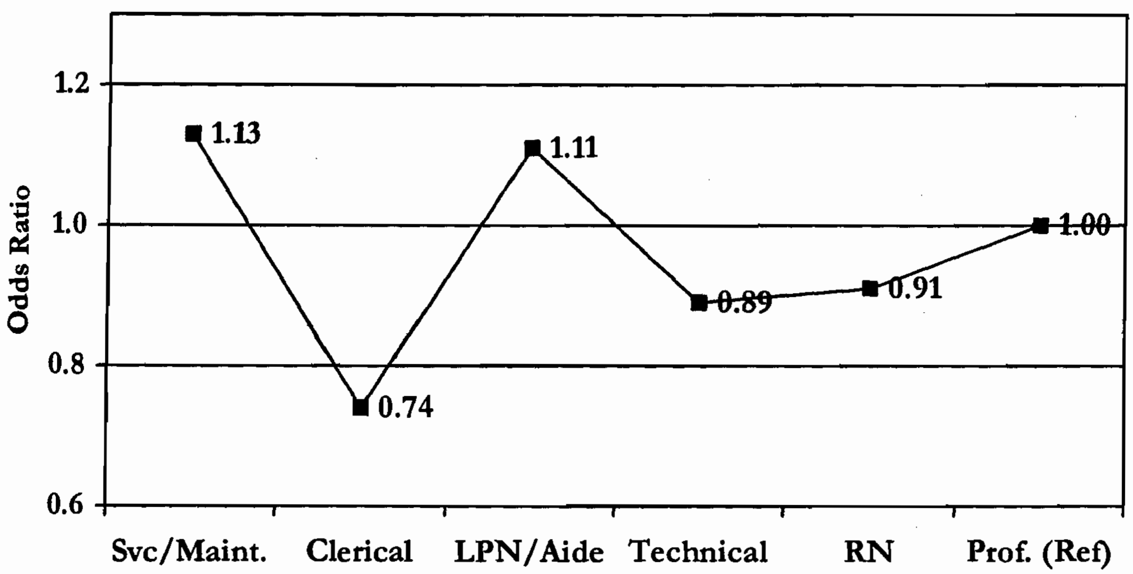
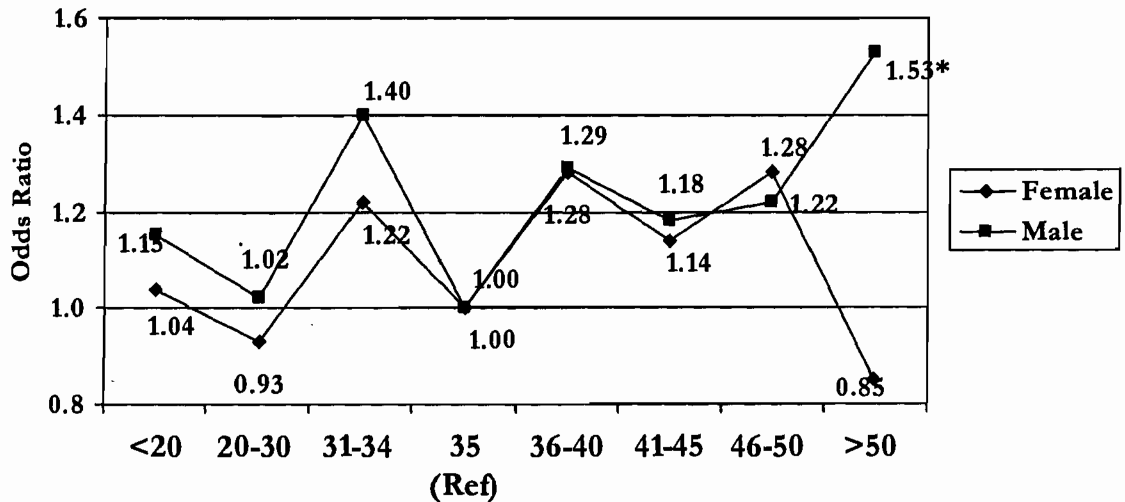


Figure 6. Risk of Heart Disease and Stroke by Job Category
Age and gender-adjusted Odds Ratios, July 1999-June 2001



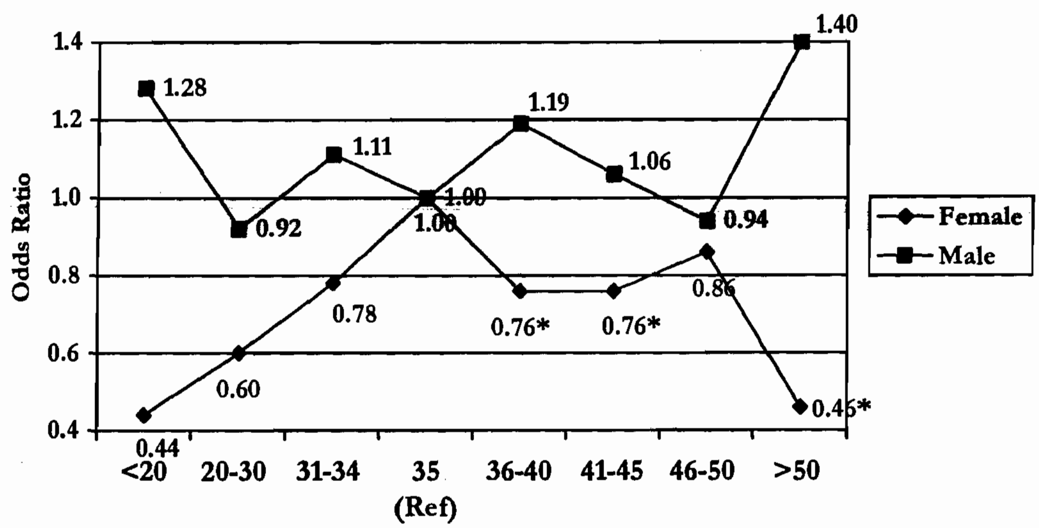
The larger sample of subjects and claims with available work hour data allowed for the categorization of work hours into narrower groups (Figures 7-12). Male employees working >50 hours per week were at increased risk of filing a medical claim for a low back MSD (OR = 1.53, 95% CI 0.92-2.55, p =.099) (Figure 7). Women working overtime were at significantly reduced

Figure 7. Risk of Low Back MSD by Weekly Work Hours for 3 Months Before Claim By Gender, Age-adjusted Odds Ratios, July 1999-June 2001



*p<.05

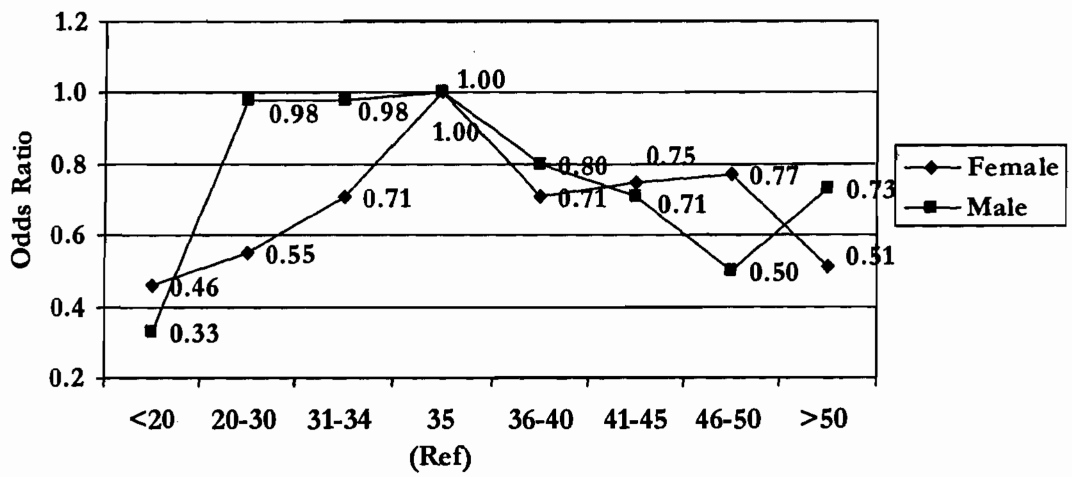
Figure 8. Risk of Neck MSD by Weekly Work Hours for 3 Months Before Claim By Gender, Age-adjusted Odds Ratios, July 1999-June 2001



*p <.05

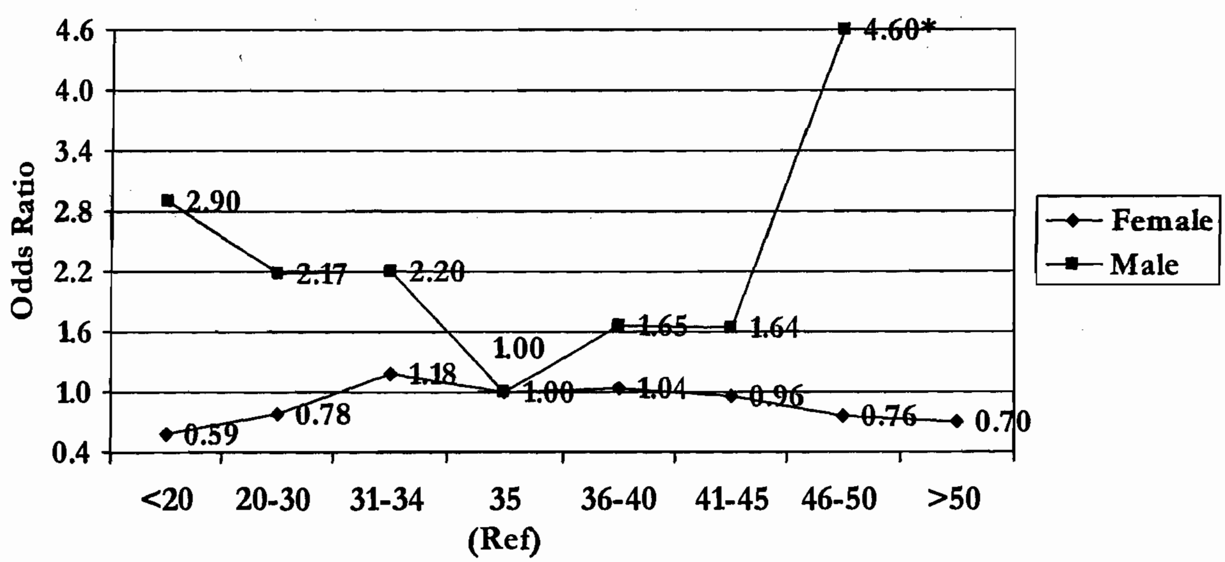
risk of neck MSDs (Figure 8). Work hours were not significantly associated with shoulder MSDs (Figure 9). Men working 46 or more hours per week were at significantly and substantially increased risk for wrist/hand MSDs (OR = 4.58, 95% CI 1.04-20.21) (Figure 10). Women

Figure 9. Risk of Shoulder MSD by Weekly Work Hours for 3 Months Before Claim By Gender, Age-adjusted Odds Ratios, July 1999-June 2001



*p < .05

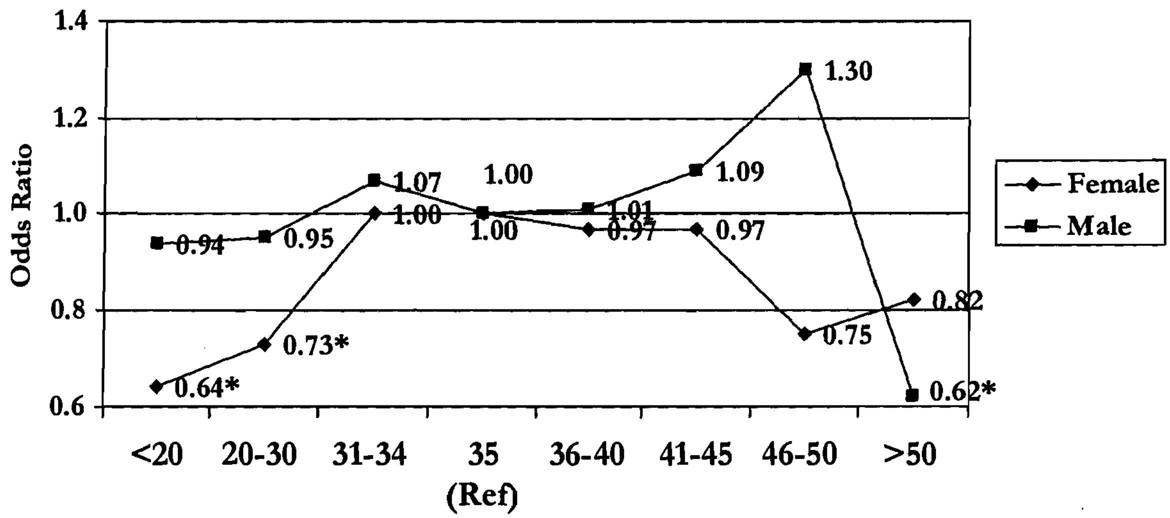
Figure 10. Risk of Wrist/Hand MSD by Weekly Work Hours for 3 Months Before Claim By Gender, Age-adjusted Odds Ratios, July 1999-June 2001



*p< .05

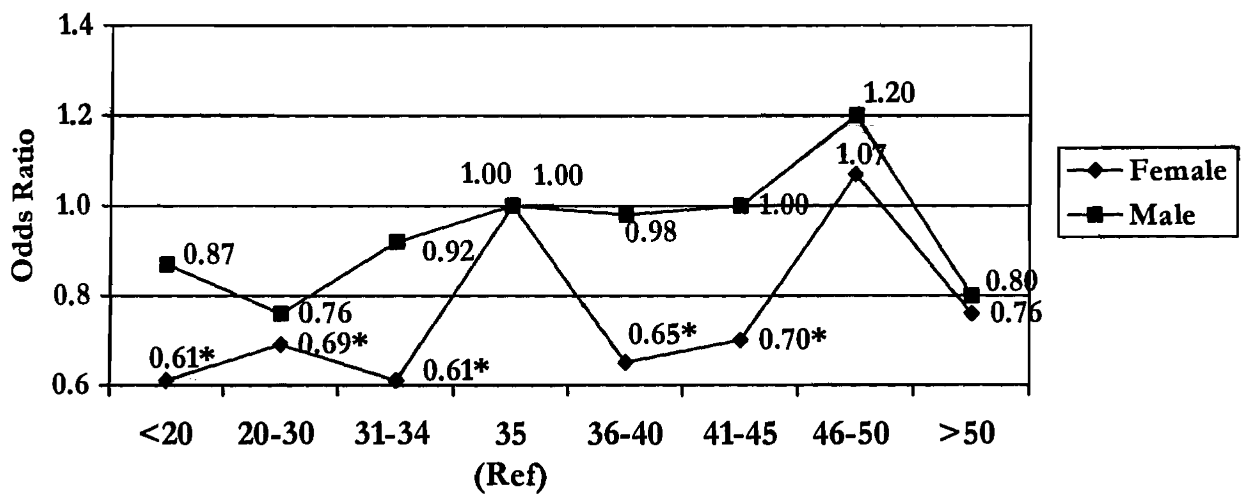
working fewer hours had a reduced risk of medical claims for hypertension: OR=0.71 (95% CI 0.53-0.95) for less than 20 hours per week and OR = .79 (.63, .97) for 20-30 hours per week (Figure 11). However, men working over 50 hours per week also had a reduced risk: OR=0.71 (95% CI 0.53-0.96). Women working more or less than the reference category of 35 hours per week had increased risk of filing a claim for heart disease or stroke (Figure 12).

Figure 11. Risk of Hypertension by Weekly Work Hours for 3 Months Before Claim By Gender, Age-adjusted Odds Ratios, July 1999-June 2001



*p< .05

Figure 12. Risk of Heart Disease and Stroke by Weekly Work Hours for 3 Months Before Claim, By Gender, Age-adjusted Odds Ratios, July 1999-June 2001



*p< .05

Interaction between work hours and job category

Since the work hour by gender analyses (Figures 7-12) may be confounded by job exposures and socioeconomic status (SES), ideally both work hours and job category need to be included in the same analysis. Due to the limited proportion of subjects with job title data, such analyses will likely be underpowered. However, to improve statistical power, we collapsed our prior eight work hour categories into two categories: >40 hours per week vs. 31-40 hours per week (reference group). The combination of six health outcome measures and six job categories yielded 36 comparisons. However, only one of those tests was significant at p<.05: RNs working >40 hours per week were at increased risk of hypertension, OR= 2.87 (95% CI 1.29-6.37). An additional six comparisons yielded an OR with a magnitude >1.6 or <0.6 (Table 6). LPNs working >40 hours per week had an elevated risk of heart disease/stroke and technical employees working >40 hours per week had an elevated risk of neck MSDs. On the other hand, four risk estimates were below 0.6 suggesting decreased risk if working >40 hours per week: wrist/hand MSDs for service/maintenance workers and LPNs, and hypertension and heart disease/stroke for technical workers.

Table 6. Associations between risk of MSD or CVD and ≥41 hours worked per week (vs. 31-40 hrs/wk), by job title, age and gender-adjusted odds ratios (if >1.6 or <0.6, minimum 10 cases)

	Cases	Job category	Hours/wk	OR	95% CI	p
Neck MSD	27	Technical	≥41	1.63	0.64-4.15	.31
Wrist/Hand MSD	13	Service/maint	≥41	0.37	0.04-3.16	.36
Wrist/Hand MSD	18	LPN	≥41	0.15	0.02-1.13	.07
Hypertension	81	Technical	≥41	0.53	0.25-1.12	.096
Hypertension	54	RN	≥41	2.87	1.29-6.37	.01
Heart Disease/Stroke	34	LPN	≥41	1.87	0.80-4.37	.15
Heart Disease/Stroke	28	Technical	≥41	0.42	0.14-1.22	.11

To further explore associations with work hours, we examined employees working ≤30 hours per week vs. 31-40 hours per week (reference group). Out of 36 comparisons, none were significant at p<.05, but nine estimates were >1.6 or <0.6 (Table 7). Reduced risk was observed for neck MSDs and wrist/hand MSDs for LPNs, hypertension for professionals, and heart disease/stroke for clerical and technical employees. However, increased risk was observed for wrist/hand MSDs for service/maintenance and clerical workers, hypertension for RNs, and heart disease/stroke for LPNs. Overall, half of the 16 comparisons in Tables 6 and 7 were in the hypothesized direction and half were not.

Table 7. Associations between risk of MSD or CVD and ≤30 hours worked per week (vs. 31-40 hrs/wk), by job title, age and gender-adjusted odds ratios (if >1.6 or <0.6, minimum 10 cases)

	Cases	Job category	Hours/wk	OR	95% CI	p
Neck MSD	38	LPN	≤30	0.48	0.14-1.68	.25
Wrist/Hand MSD	13	Service/maint	≤30	1.68	0.38-7.42	.49
Wrist/Hand MSD	36	Clerical	≤30	1.84	0.72-4.68	.20
Wrist/Hand MSD	18	LPN	≤30	0.40	0.09-1.84	.24
Hypertension	54	RN	≤30	1.76	0.65-4.74	.27
Hypertension	32	Professional	≤30	0.56	0.08-3.96	.56
Heart Disease/Stroke	39	Clerical	≤30	0.52	0.15-1.80	.30
Heart Disease/Stroke	34	LPN	≤30	1.62	0.61-4.28	.33
Heart Disease/Stroke	28	Technical	≤30	0.25	0.05-1.22	.09

DISCUSSION

Based on incident medical claims filed by New York City hospital workers, men were at increased risk for low back MSDs, although national studies have shown similar prevalences for men and women (25). Men were at increased risk for hypertension, heart disease and stroke compared to women, consistent with other studies of hypertension (26), and CVD incidence (27) among individuals less than 60 years of age. Female hospital workers in this data set were at increased risk for wrist/hand MSDs, also consistent with prior studies (28).

Work hours. Increased weekly work hours were associated with low back and wrist/hand MSDs among men, suggesting that the association observed between MSDs and greater duration of exposure to physical risk factors over a work day (11, 14) would also apply to long work weeks. However, contrary to expectations, there was a tendency toward decreased MSD and CVD risk associated with longer work hours among women.

Job categories. Employees in job categories with higher levels of ergonomic risk factors tended to have higher MSD risk. Service/Maintenance workers and LPN/aides were at increased risk for low back MSDs. In addition, several associations, while not statistically significant were substantially elevated (OR≈3.0), that is, Service/Maintenance workers and Clerical workers were at increased risk of wrist/hand MSDs. There were no clear patterns for associations between job categories and hypertension and CVD, not consistent with studies showing increased risk of hypertension (26) and CVD incidence (29) among workers with lower SES.

Work hours by job category. It has been hypothesized that long weekly work hours would increase risk of MSDs primarily among workers facing ergonomic stressors (13, 30). Similarly, long weekly work hours would increase risk of CVD primarily among workers facing psychosocial stressors (31-33). Thus, the interaction between job category (a proxy for ergonomic and work stress exposures) and work hours should yield the most valid patterns of results. Unfortunately, those analyses were limited in the present study due to the low proportion of subjects with available job title data. Only one of the 36 comparisons of overtime work (vs. a "normal" work week) was significant at $p<.05$. RNs had a substantially increased risk of filing a medical claim for hypertension (OR=2.87, 95% CI 1.29-6.37, p=.01). However, the remaining patterns of association could be compatible with both the long work hours → disease (increasing exposure-increasing disease risk) hypothesis, or the disease→ shorter work hours (health worker effect) hypothesis.

Strengths of study

The major strengths of the study were its use of objective measures of work exposures (work hours and occupational status) as well as disease. Hours worked per month is a valid indicator of the employees' work hours since the employees are hourly employees. Use of administrative data bases avoids the burden of convincing subjects to complete surveys or undergo medical tests in epidemiologic studies The results are also representative of all hospital workers in a major metropolitan area. A major value of analyses of medical claim databases is in hypothesis generation, not only hypothesis testing. The current study identified hospital worker job categories at increased risk of disease that need further epidemiologic and intervention research.

Limitations of study

Findings not consistent with prior research might be explained by the study's limitations. As with all studies of administrative data bases not initially designed for health research, few confounders or work exposures are available. In this data set, the limited number of individuals with job title data prevented us from fully examining job by work hour interactions.

Exposure misclassification due to lack of data on second job or part-time/full-time status would be differential, biasing results to the null. In any study of long work hours, there is the inherent difficulty in disentangling overtime effects from the healthy worker effect. For example, the possible reduction of work hours due to early stages of illness would bias results to the null (although we reduced this bias by not counting hours worked in the same month as the claim).

The inclusion of claims for diseases that may not have been work-related also introduced (non-differential) disease misclassification, with a resulting bias to null.

Future Research on Extended Work Hours

This study, and the other studies included in this Final Report, were the first studies of long work hours and hypertension and CVD risk in women. This was also one of the few studies of hospital worker health not primarily focused on nurses, but focusing on other hospital workers. Our future studies will address these issues by collecting self-report data on job title, hours worked in second job, and potential confounders. We will also be able to collect individual data on CVD risk factors such as blood pressure. In addition, the database used in the present study also contains data on disability, pharmacy use and hospital visits.

There remains a great potential for the use of medical insurance claim data bases in occupational disease surveillance, particularly for conditions not typically considered work-related, such as cardiovascular disease. Surveillance would be greatly enhanced by further efforts to combine medical claim datasets with demographic employee datasets that contain detailed information about job title, work history, and perhaps other work exposures.

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STUDY #2

EXTENDED WORK HOURS, ERGONOMIC RISK FACTORS AND MUSCULOSKELETAL DISORDERS AMONG HEALTH CARE WORKERS: A CASE-CONTROL STUDY

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ABSTRACT

This study was designed to examine associations between work hours and work-related musculoskeletal disorders (MSDs) among hospital workers in New York City, using data from joint union-management self-insured fund, which includes medical claims from unionized hospital workers in the New York City metropolitan area.

Potential incident cases were the first claim for any upper extremity or low back MSD, without a previous MSD, cardiovascular disease (CVD) or surgery claim in the prior six months. Potential controls were incidence-density-matched to cases by month of selection, and included all claimants with conditions not presumed to have extended work hours as etiological factors. Potential controls were excluded if they had an ICD9 code, in the 6 months prior to the index claim, for any MSD, CVD, or surgery. To be eligible, potential cases and controls also had to have 12 prior months of work hour and claim history in the insurance fund database. 1737 cases and 1737 controls meeting these criteria were identified from the database. 50 cases and 45 controls were contacted, agreed to participate, and completed a questionnaire.

Controls participating in the questionnaire study had significantly greater work hours in the 4-6 month period than the original pool of potential controls, suggesting that selection bias was operating against the hypothesis of an association between work hours and case status. Neither work hours in the 1-3 month time period nor the 4-6 month time period before the claim date were significantly associated with case-control status in age- and gender-adjusted analyses.

These results provide stronger support for the hypothesis that a developing injury led to shorter work hours (healthy worker effect) rather than longer work hours increasing disease risk. Future analyses will assess additional time windows prior to filing a medical claim, as well as self-reported ergonomic and psychosocial work stress exposures and additional confounders.

INTRODUCTION

Associations have been observed between extended work hours and a variety of health outcomes (1-4), however, few studies have examined associations between weekly or monthly work hours and musculoskeletal disorders (MSDs). Work hours were associated with hand/wrist MSDs among newspaper employees (5) and "extensive" overtime was associated with hand/arm discomfort among computer workers (6). However, overtime was not associated with records of lost-time hand/wrist MSDs among bank customer service workers (7). In Stockholm, overtime was a risk factor for low back pain for men only in combination with poor social relations (8). On the other hand, a substantial body of literature has linked MSD symptoms and/or diagnoses with increased duration of exposure to physical risk factors over a work day (6, 9-11), in particular for computer workers (12-14), suggesting increased risk in employees working longer work weeks or months.

The current study was designed to examine associations between work hours and low back and upper extremity MSDs. Participants were recruited from claimants to a joint union-management self-administered and self-insured fund, which includes medical claims from unionized hospital workers in the New York City metropolitan area.

METHODS

The 1199SEIU National Benefit Fund (NBF) is a joint union-management self-insured fund that contains a computerized database with all medical, drug, hospital, disability and workers' compensation claims made by over 100,000 health care employees at all major New York City hospitals. The Fund covers about two-thirds of all 1199SEIU members in New York City (15). The database includes ICD9 codes and basic demographic data (age, gender, hours worked per month, income and job category for some members).

Potential study participants were recruited from all hospital workers working at 22 hospitals in New York City that had filed claims with the NBF for payment of expenses due to visiting a health care provider, including those whose claims were referred to the workers' compensation system due to apparent work-relatedness of the injury or illness. The NBF provided study staff with a list of all claimants during four periods of time: August-September 2003 (cohort 1), October-December 2003 (cohort 2), January-March 2004 (cohort 3), and August-September 2004 (cohort 4). Study staff produced a roster of all potential cases and controls meeting eligibility criteria, and then attempted to recruit and screen participants from this roster using procedures described below. Data files provided to study staff from the NBF included ID number, ICD9 code, claim date, age, gender, hire date, and monthly work hours for each of the 12 months preceding the claim date.

Case and control definitions

Case and control definitions are listed in Table 1. ICD9 codes for MSD cases include those used in a study of occupational disease surveillance at an automotive factory (16). ICD9 codes for cardiovascular disease (CVD) cases are those commonly examined in studies of stress-related CVD conditions (17). ICD9 codes for controls include conditions that are not presumed to have extended work hours, ergonomic risk factors or work stressors as etiological factors, including dermatological conditions, congenital anomalies, and benign gynecological conditions.

Eligibility criteria

Potential incident cases were defined as all claimants for MSD ICD9 codes (Table 1) who

Table 1. Definitions of case and control conditions	
Musculoskeletal Disorders	**ICD9 Code**
Low Back	721.2-721.4X, 722.1X, 722.5X, 722.72, 722.73, 722.92, 722.93, 724.XX, 846.X, 847.2, 847.3, 847.4, 847.9
Neck	721.0, 721.1, 722.0. 722.4, 722.71, 722.91, 723.X, 847.0
Shoulder	715.11, 726.0, 726.1X, 726.2, 727.61
Wrist/Hand	354.0, 354.1, 354.3, 443.0, 715.14, 726.4, 727.01, 727.04, 727.05, 727.09, 727.4, 727.41, 727.42, 727.49
Other Upper Extremity	337.21, 353, 354.2, 354.4-9, 715.12-14, 726.3, 726.39, 726.4, 726.9, 726.91, 727.03, 727.2, 727.43
Cardiovascular Disease	
Hypertension	401-404.9
Heart Disease and Stroke	410-414.9, 430-438.9, 440-440.9
Controls	
Anemia	280-280-9
Congenital Anomalies	740-759.9
Dermatological Conditions	680-709.9
Ear Conditions	380-382.9
Genito-Urinary Conditions	580-629.9
Hepatitis	573-573.9
Hernia	550-550.9
Acute injuries	800-959.9
Neoplasms	140-239.9
Ocular Conditions	361-361.9, 365-365.03, 364.1-367.9
Pregnancy	650-651.9
Respiratory Conditions	460-519.9

had 12 prior months of work hour and claim history. Potential incident cases were ineligible if they had an ICD9 code, in the six months prior to the index claim, for an MSD in the same anatomical region (to define incident cases), other MSDs (since other MSDs may be related to claim of interest), CVD (which may be related to exposure of interest, work hours), and surgery (which may be cause of musculoskeletal pain).

Potential controls were defined as all claimants for control ICD9 codes (Table 1) incidence-density-matched to cases by month of selection, that is, chosen at the same time as cases to allow for estimation of relations among incidence rates (18). When more than one potential control existed for a single case, a single control was randomly drawn for the case. To be eligible, potential controls also had to have 12 prior months of work hour and claim history. Potential controls were excluded if they had an ICD9 code, in the 6 months prior to the index claim, for any MSD, CVD, or surgery. Potential cases and controls at the hospital employing study staff were oversampled 2:1 to facilitate recruitment and survey administration.

Hours worked during the month that the claim was filed was not included in analyses since it would be unknown whether overtime hours (if any) were worked before or after the claim was filed. This exclusion also reduces the potential bias of injury or illness leading to fewer work hours.

Recruitment procedures

Study staff prepared a roster of individuals (by ID) whose ICD9 codes met the definitions for potential case and control and provided it to the NBF. The NBF notified all potential study participants by mail about the study and requested that the individuals contact the NBF if they did not wish to be contacted by study staff. After deleting information for those who chose not to participate (very few individuals), the NBF provided study staff with a roster of names, addresses and phone numbers of all potential cases and controls. A total of 50 cases and 50 matched controls were selected from cohort 1, 386 cases and 386 controls from cohort 2 (of which we attempted to contact a random sample of 133 cases and 133 controls), 794 cases and 794 controls from cohort 3, and 507 cases and 507 controls from cohort 4; a total of 1737 potential cases and 1737 potential controls. Study staff attempted to contact those individuals by phone, administer informed consent, and administer a screening questionnaire to further determine eligibility for the study. Due to the time consuming nature of attempting to reach those individuals by phone, study staff was only able to attempt to contact 665 cases and 701 controls (Table 3).

Telephone eligibility screen

Potential participants were asked a number of questions to confirm electronic data provided by the NBF regarding the index medical claim (Table 2). Potential cases were considered ineligible if they did not report any pain or discomfort in the upper extremity or low back in the past year (including the date of the medical claim); if the anatomical area of pain and discomfort did not match the area identified by the medical claim; if they had not seen a doctor, nurse or other health care provider because of the pain or discomfort; if the date of the doctor's visit they provided was more than 6 months different from the date of the medical claim; or if the pain or discomfort was due to major surgery, acute injury, arthritis, sports, hobby or pregnancy.

Potential controls were considered ineligible if they had seen a doctor, nurse or other health care provider because of upper extremity or low back pain or discomfort in the past year; if the pain or discomfort was experienced once per week or more; if the pain or discomfort was described as ≥4 on a scale of 1 to 10; or if the pain or discomfort was "due to your work".

Table 2. Telephone screen for study eligibility

		Potential cases	Potential controls
Q1: upper extremity, low back pain in past 12 months:	Yes	• If same body part as claim → **Eligible**, continue with work-related questions • If several body parts, must include claim for body part → **Eligible**, continue w/ work-related questions	• Ask Q5, frequency, Q6, intensity: If Q5 = once/month or less AND if Q6 ≤3 → **Eligible**; • If Q5 > once/month OR if Q6 ≥4 → **Ineligible**
	No	• **Ineligible**	• **Eligible**
Q7: symptoms due to injury or surgery	Yes	• **Ineligible**	• **not applicable**
	No	• **Eligible**, continue w/work-related questions	• not applicable
Q 8, 9, 10, 11: work-relatedness	Yes	• If yes to any of four questions → **Eligible**	• If yes to Q8, due to your work → **Ineligible**
	No	• **Ineligible**	• not applicable

Summary of participant selection

A total of 50 cases and 45 controls were found to be eligible, agreed to participate and completed the study questionnaire (Table 3). The participation rate was 27.3% for cases and 19.4% for controls.

Table 3. Summary of participant selection		
	Cases	Controls
	N	N
Potential cases and potential controls	**1737**	**1737**
-Bad address from NBF mailing	-23	-34
-No longer eligible for NBF	-22	-26
-Refused to participate	-32	-26
-Removed duplicates from earlier cohorts	-42	-38
-Randomly chosen not to be selected from cohort 2	-352	-352
Total phone numbers given to study staff	**1266**	**1261**
Total individuals called by study staff	**665**	**701**
-Disconnected phone	49	70
-No answer	104	106
-Bad phone number	124	109
Total assumed correct phone numbers	**388**	**416**
-Left message, no reply (passive refusal)	86	112
-Refused to participate	122	141
Agreed to participate	**180**	**163**
Ineligible	95	72
Eligible	85	91
Eligible and completed questionnaire	50	45
Proportion of agreed + eligible who completed questionnaire (p_1)	58.8%	49.5%
Participation rate (agreed to participate*(p_1))/correct phone numbers)	**27.3%**	**19.4%**
Note: Participation rate is based on the assumption that if ineligibles who agreed to participate were eligible, they would have completed the questionnaire at the same proportion (p_1) as the eligibles. For cases, rate=180*0.588)/388=27.3%; for controls, rate=163*0.495)/416=19.4%.		

Symptom and demographic questionnaire

Following screening by phone for eligibility, participants were mailed and completed a questionnaire packet, which included questions on MSD symptoms and demographics.

The hospital workers union, 1199SEIU, had created six job categories for hospital work for administrative purposes. These categories, in order of increasing status, were service/

maintenance, clerical, licensed practical nurse (LPN)/aide, technical, registered nurse (RN) and paraprofessional. See Table 3 for detailed job titles included in each category. Participants were asked to write their job title and record into which job category it fit.

Table 4. Examples of job titles within each hospital employee job category	
Job category	**Examples of job titles**
Paraprofessional	social worker, physicians' assistant, perfusionist, emergency medical technician, pharmacist
Registered Nurse	registered nurse
Technical	operating room, laboratory, radiology, ultrasound, tomography, other diagnostic procedures technicians and technologists; rehabilitation, physical, occupation, recreational and speech pathologists or therapists
LPN/aide	Licensed Practical Nurse, certified nurse assistant, direct patient care worker having minimal credentials
Clerical	clerk, secretary, intake and discharge representative, accounts payable and receivable representative, unit head, administrative assistant, receptionist, telephone operator
Service/Maintenance	food service/preparation, housekeeper, janitor, groundskeeper, storekeeper, porter, painter, plumber, carpenter, electrician

A symptom checklist was derived from the questionnaire used by the Mount Sinai Center for Occupational and Environmental Medicine, a modification of a questionnaire initially developed by the National Institute for Occupational Safety and Health (19). Participants were asked whether they had any long-lasting discomfort in their hands, wrist, fingers, arms, shoulders, neck or low back, including pain, numbness or tingling, during the last year. If yes, they were asked, for each anatomical region, during the month they filed the medical claim, the level of pain (none, mild, moderate, severe, unbearable), the frequency of symptoms (daily, once a week, once a month), whether the pain caused by or made worse by work (yes/no), when did the symptoms first develop (month/year) and how many workdays did you lose in the last year, due to this pain?

Questions on demographics (gender, race/ethnicity, age, education, income, and marital status), smoking, height and weight were derived from the New York City Work Site Blood Pressure Study (WSBPS) questionnaire (20, 21). Body mass index (BMI) was computed as weight (kg)/height (m)^2. Current smoking was based on one question ("do you smoke cigarettes?" (yes/no)), which had a three-year test-retest reliability of 0.69 (kappa) in the New York City WSBPS. Based on the Mount Sinai Center for Occupational and Environmental Medicine questionnaire, participants were asked if they had ever been told by a doctor that they had any of a list of medical conditions (including diabetes, kidney disease, thyroid problem) that could contribute to the development of an MSD.

Computation of work exposures

Work hours. Based on data provided by the NBF on hours worked per month, total hours worked in the 3 months prior to the medical claim (for cases) and for the corresponding 3 months (for controls) was computed. In addition, cumulative work hours during the 4-6 month period prior to the medical claim were computed since symptoms may have developed weeks or months before the date of the visit to a health care provider with a corresponding reduction in work hours due to symptoms. We expect that the work hour level 4-6 months prior to the medical claim will be more strongly associated with case-status than the 1-3 month total.

Data analysis

Missing data were imputed using "hot deck" method, which draws imputed values at random from the cohort. Unlike substitution by means, the standard deviation of data sets imputed with hot deck method is, on average, the same as the standard deviation calculated from the data set excluding missing data. Because the sample standard deviation is not artificially deflated as it is using substitution by means, hypothesis testing using hot-deck imputed data is more conservative, meaning a Type I statistical error because of artificially reduced variance estimates will not occur.

Assessing potential selection bias. In order to assess whether the participant selection process introduced bias into the selection of the final group of 50 cases and 45 controls, we compared the original group and the final group on exposure (work hours) and on available demographic measures, age and gender. Comparisons between the original sample of potential cases and controls and the final group of cases and controls for age and work hours were conducted by Mann-Whitney U test and for gender by chi-square test.

Bivariate analyses. Odds ratios expressing the association between work-hours (categorized into quartiles) and case-control status are computed using logistic regression.

Multivariate analyses. Multivariate-adjusted odds ratios expressing the association between work hour quartile and case-control status are computed using logistic regression. Analyses are adjusted for age and gender.

RESULTS

There were only one significant difference between potential and final cases or potential and final controls on the exposure of interest (past work hours), or age or gender (Table 5). The controls participating in the questionnaire study had significantly greater work hours in the 4-6 month period than the original pool of potential controls. This suggests that selection bias was operating against the hypothesis of work hours being positively associated with case status for the 4-6 month time window.

Neither work hours in the 1-3 month time period nor the 4-6 month time period before the claim date were significantly associated with case-control status in age- and gender-adjusted analyses (Table 6). However, this null result was not due to limited statistical power. In fact, on average, controls worked longer hours during these time periods than cases.

Table 5. Assessment of selection bias						
	Cases			Controls		
	Potential	Final	p	Potential	Final	p
N	1737	50		1737	45	
Monthly work hours prior to claim date (mean)						
1-3 months prior	137.5	133.2	.72	141.7	137.2	.56
4-6 months prior	123.6	118.3	.35	119.6	133.4	<.01
Age (mean)	45.9	46.4	.80	43.4	46.7	.32
Gender (% female)	72.6%	82.0%	.14	77.7%	71.1%	.29

Comparisons for age and work hours were tested using the Mann-Whitney U test; comparisons for gender were conducted using the chi-square test.

Table 6. Risk of being an MSD case, by monthly hours worked be fore a medical claim was filed (50 cases and 45 controls)						
	Crude			Adjusted for age, gender		
	OR	95% CI	p	OR	95% CI	p
Work hours 1-3 months prior to claim date	1.11	0.73-1.69	.62	0.82	0.34-1.98	.65
Work hours 4-6 months prior to claim date	0.57	0.37-0.89	.01	0.76	0.35-1.63	.46

Note: Odds ratios reflect the change in risk of being an MSD case due to increasing work hours by quartile of the work hour distribution.

DISCUSSION

New York City hospital workers who filed medical claims for low back or upper extremity MSDs did not work longer hours in the 1-3 month and 4-6 month periods before their medical claim, than hospital workers filing claims for respiratory, dermatological, neoplasms, or other conditions not thought to be associated with long work hours or work stress. These findings do not provide support for the hypothesis that the association observed between MSDs and duration of exposure to ergonomic risk factors over a work day (5, 6, 9) would also apply to long work weeks or months. Patterns of association for the six months before the medical claim date are more compatible with or the disease→ shorter work hours (healthy worker effect) hypothesis than the long work hours → disease (increasing exposure-increasing disease risk) hypothesis.

Despite the small number of participants who could be reached by phone, who were eligible, who agreed to participate and who completed the questionnaire, there was no evidence of selection bias, except for hours worked in the 4-6 month time window before a medical claim was filed. For that measure of exposure, selection bias was operating against the hypothesis of work hours being positively associated with case status.

Strengths of study

The major strengths of the study were its use of objective measures of work hours and MSDs. Hours worked per month is a valid indicator of the employees' work hours since the employees are hourly, not salaried, employees. The results are also representative of all hospital workers in a major metropolitan area. This study was one of few studies of hospital worker health not primarily focused on nurses, but focusing on other hospital workers.

Limitations of study

Possible explanations for the null results are the study's limitations. As with all studies of administrative data bases not initially designed for health research, few confounders or work exposures are available. (Only age, gender and work hours were available in the medical claim database.) Exposure misclassification due to lack of data on hours worked on a second job would be non-differential, biasing results to the null. In any study of long work hours, there is the inherent difficulty in disentangling overtime effects from the healthy worker effect. For example, the possible reduction of work hours due to early stages of illness would bias results to the null (although we reduced this bias by not counting hours worked in the same month as the claim, and by examining work hours in the 4-6 month period prior to a medical claim).

An additional limitation was the fact that potential cases and controls worked at 22 different hospitals in New York City, thus preventing study staff from being able to recruit them to the study in person. Our experience was more positive in study #4 in which all hospital participants worked at one hospital and therefore could be approached and study details discussed in person.

Our participant telephone-screening questionnaire did reduce one potential source of bias. We eliminated from the smaller sample MSD cases for conditions that may not have been work-related, and eliminated control conditions that may have been work-related.

Future analyses

Funding was not available to complete an assessment of ergonomic (occupational and non-occupational physical demands), psychosocial risk factors, and other risk factors in the smaller sample that completed the study questionnaire. Funding will be raised in the future to complete such analyses. Future analyses will assess additional time windows prior to filing a medical claim, for example, 3-9, 6-9 and 6-12 months before exposure. For example, it has been hypothesized that long weekly work hours would increase risk of MSDs primarily among workers facing ergonomic stressors (8, 22). Thus, the interaction between work hours and self-reported ergonomic and psychosocial work stress exposures should yield more valid results for the impact of work hours on MSD risk.

There remains a great potential for the use of medical insurance claim databases in occupational disease surveillance. Surveillance would be greatly enhanced by further efforts to combine medical claim datasets with demographic employee datasets that contain detailed information about job title, work history, and perhaps other work exposures. This would permit analyses of existing merged data sets and eliminate the time consuming work of attempting to reach individual study participants. Such merged datasets would primarily be used for hypothesis generation. However, the collection of detailed information on exposure and confounders needed for hypothesis testing will necessarily require a great deal more resources given the large burden on study staff to recruit participants and administer questionnaires on an individual basis.

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STUDY #3

OVERTIME, SHIFT WORK AND AMBULATORY BLOOD PRESSURE AMONG FEMALE NURSES

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BACKGROUND

This section provides an overview of past research on the effects of long work hours, and in particular, their cardiovascular-related effects, including hypertension and myocardial infarction. The methodological issues encountered in conducting research on long work hours and the evidence supporting the superiority of ambulatory blood pressure (ABP) monitoring over casual blood pressure monitoring in the measurement of blood pressure are also described. Next, an overview of a related topic – the cardiovascular effects of shift work – is provided to explore the implications of that body of research for research on long work hours. With this background, the paucity of research on the effects of long work hours in women and the suitability of nurses as an occupational group for this type of research is established. At the end of this section, study hypotheses are described: the association of ABP in female nurses and nurses' aides work hours on the day of ABP monitoring, during the two-week period of ABP monitoring and during the 2-4 weeks immediately prior to the ABP monitoring.

Overview of Research on Long Work Hours

In the United States, the average annual number of hours worked per person now exceeds the average number of hours worked in Japan and most of Western Europe (1). A growing body of research has demonstrated that long work hours affect workers negatively in numerous ways, including job safety, by increasing the risk of injury (2) and accidents (3), decreasing cognitive and executive function (4), lowering productivity (5), creating job dissatisfaction (6), necessitating a longer recovery period from work (7), and resulting in a poorer quality of life (8). Extended work hours also have a negative impact on workers' mental and physical health.

Research has linked overtime hours to decreased psychological well-being (9) and depression (10), as well as physical health effects such as increased neck and musculoskeletal discomfort (11, 12), alcohol use (13), decreased sleep (8, 14), disturbed sleep, and chronic fatigue (15). Long-term health effects include the development of coronary artery disease (16), non-insulin–dependent diabetes (17, 18), obesity (19), changes in womens' menstrual cycles (20), and increased mortality (21).

As productivity among workers continues to increase in industrialized countries and work hours lengthen (22), it is important to determine the effects of long work hours on workers. However, any study of long work hours faces several methodological issues. First, the definition of long work hours varies by country, study, and industry. For example, European studies and reviews define "long work hours" as greater than 50 hours per week, whereas some Japanese studies define it as greater than 60 hours per week. There are also different components to the work schedule, including the shift time (day, evening, or night), whether the shift is fixed or rotating, shift length, weekend work, weekly overtime, degree of worker control over work times, number of consecutive workdays before a rest day, number of rest days, and number of weekends off (22), all of which can complicate efforts to isolate the effect of overtime work from the effects of shift work, length, and number of days worked, as well as other components of the job such as workload and occupational stress (23). Steenland suggests that the assessment of long work hours as a risk factor for heart disease is difficult to separate from the more general literature on occupational stress since overtime work by its very nature is considered stressful (24).

In addition, commute time is usually not factored in as part of the number of hours worked, but it can lengthen the workday and contribute to the effects of long work hours.

Kageyama et al. (25) examined overtime and commuting time and found that the groups with the longest overtime hours (60 hours or more overtime per month) and the groups with the longest commuting time (90 minutes or more) were in a sympathodominant state, as measured by their heart rate variability, suggesting a possible mechanism by which long work hours and commuting times can induce cardiovascular abnormalities related to the onset of heart disease.

Studies on overtime also have a difficult time capturing the complete overtime history from participants. For example, although Nylen et al. (21) found that lengthy working hours were associated with increased mortality in Swedish men and women, even after controlling for confounders such as age, marital status, children, smoking and alcohol use, sleeping pills, stress, shift work, personality, and illness, their measure of overtime work gives a poor sense of participants' overtime history since the survey only asks about overtime at one point in time (1973), and the participants were not asked how many years they had worked overtime or if they had worked overtime hours prior to 1973. The study had a 24 year follow-up to assess all-cause mortality. Given the positive findings despite the poor overtime history, the actual association between overtime work and mortality could actually be stronger than that found by Nylen et al.

In addition to varying definitions of overtime work, other methodological issues include selection bias, study design, outcome measures, and control for possible confounders (20). First, the study population can be a self-selected population based on their voluntary willingness to work long hours. As time passes, the remaining workers who work overtime are more likely to be a survivor population. Second, past studies examining the effects of overtime have usually been cross-sectional in design. More studies are needed that are longitudinal to determine the causal association between overtime hours and its effects. Third, outcome measures in long work hours research have been "soft" measures such as fatigue, mood, or job performance. The complex interplay of outcome measure determinants such as gender, individual characteristics (e.g. personality type) and situational factors (e.g. work type, work-home interface) can further complicate the study of outcome measures associated with overtime hours. Lastly, studies need to better control for potential confounders. In a review of the literature on long work hours, van der Hulst (26) found that the evidence for the association between extended work hours and health is usually inconclusive because many studies do not control for possible confounders such as demographic variables, work characteristics, home characteristics, and personality that can affect the health outcome measures.

Effect of Overtime Work Hours on Cardiovascular Risk

Cardiovascular disease presents a major public health burden as it is the leading cause of morbidity and mortality for both men and women in the United States. The Centers for Disease Control estimates that 370,000 American women of all races and ethnic groups die from heart disease each year (27). While the morbidity and mortality associated with coronary heart disease in men is well-recognized, the magnitude of the problem in women has often been overlooked (28). An association has been observed between long work hours, cardiovascular disease and elevated blood pressure in men, but few studies have included women. However, a growing body of research has emerged, such as the Framingham study (29) and a study in Gothenburg, Sweden (30), demonstrating that psychosocial characteristics such as low socioeconomic status, low educational attainment, the double loads of work and family, chronic troubling emotions, lack of social support, and psychosocial work strain are major risk factors for heart disease in women. In general though, these factors still have not been studied as extensively as in men (31, 32).

Of the research on overtime hours and cardiovascular risk conducted on men, the negative cardiovascular effects of long work hours were suspected as early as the 1950s, when Buell and Breslow examined Census data to determine the association between long work hours and mortality risk from coronary artery disease in California men (16). They found an increased risk in men less than 45 years old who worked more than 48 hours per week at jobs with light physical activity.

Among industrialized countries, Japan has studied the effects of work hours in men most extensively (33), most likely because long work hours have been common among Japanese workers and the phenomenon of "karoshi" (a sociomedical term whose literal translation is "death from overwork") is well recognized. In the 1980s, Japanese men worked the longest hours of any industrialized country (2,159 hours in 1989) and the number of male workers who worked more than an average of 60 hours per week had increased from 15% of employed male workers in 1975 to 24% of employed male workers in 1988 (34). However, the phenomenon of "karoshi" was recognized as early as 1969, and refers to sudden death that occurs from cardiovascular disease in men working under physiologically demanding work conditions such as long working hours, which have been a deeply embedded cultural norm in Japan (35). Major medical causes of karoshi are myocardial infarction and stroke, including subarachnoid or cerebral hemorrhage, cerebral thrombosis or infarction, myocardial infarction, heart failure and other causes (36). In general though, the phenomenon of karoshi and overwork have not been subjected to rigorous study designs and more research is required on this phenomenon.

Cardiovascular research has also looked specifically at the association between long work hours and acute myocardial infarction and hypertension. Past research has demonstrated that long working hours increase the risk of acute myocardial infarction, although this research has been conducted mainly in men. The nature of this association between long work hours and acute myocardial infarction is still unclear. In one case-control study of Japanese men, Sokejima et al. (37) found a U-shaped relation between mean working hours per day and the risk of non-fatal acute myocardial infarction. The risk of myocardial infarction was increased two-fold for working longer mean hours (greater than 11 hours per day) but also for working shorter than average hours (less than 7 hours per day). Also, at the top end of the curve, a greater increase in mean working hours (more than 3 hours a day in the recent past) resulted in an increase in myocardial infarction risk. The explanation provided by Sokejima et al. for the U-shaped curve is that for the men working longer mean hours, work-induced tension increased sympathetic nervous system activity and blood pressure, but for the men working shorter than average hours, the shorter hours could indicate the presence of a premorbid condition prior to the onset of a myocardial infarction, or alternatively, the shorter hours could be a causal factor in the development of a myocardial infarction, as with unemployment or deterioration in lifestyle.

Unlike Sokejima et al.'s study, Liu et al. (38) found the relation between work hours and acute myocardial infarction to be monotonic. In their case-control study of 705 Japanese men, Liu et al. found that overtime work (defined as greater than 61 hours per week) and insufficient sleep (less than 5 hours per day) increased the risk of nonfatal myocardial infarctions. In addition, lack of sleep and few days off in the recent past increased the risk of myocardial infarctions more than experiencing lack of sleep and few days off over the past year, demonstrating an acute effect.

However, some studies have found no association between long work hours and cardiovascular risk factors. In a cross-sectional study, Sasaki et al. (39) found no significant relationship between work hours and the cardiovascular system. After measuring heart rate variability, blood pressure, serum magnesium, dehydroepi-androsterone sulfate (DHEA), and cholesterol levels, they found no significant relationship between work hours and the cardiovascular variables, but they did find that sleep hours were negatively related to work hours and DHEA was positively related to sleep hours. However, their study sample consisted of a very young cohort with a mean age of 36.7 years.

Overtime Work Hours and Hypertension

The research conducted to date on the association between overtime work hours and hypertension has also demonstrated mixed results. Two excellent studies by Hayashi et al. (40) and Iwasaki et al. (41) have demonstrated that long work hours can increase blood pressure. The most closely related study to our current study, Hayashi et al. (40), found that long hours can increase a worker's average blood pressure over 24 hours. The researchers obtained 24-hour blood pressure measurements (recorded hourly) among several groups of male white collar workers at an electrical goods manufacturing company: men with normal blood pressure, men with mild hypertension, and a third group with normal blood pressure who periodically worked overtime and were measured both during periods of normal work hours and periods of overtime hours. Participants were placed in the overtime category if they worked more than 60 overtime hours per month. The groups with normal blood pressure and slightly elevated blood pressure were further subdivided into a group working overtime and a group not working overtime.

Hayashi et al. found that the 24-hour average blood pressure of the overtime group (both in men with normal blood pressure and mild hypertension) was higher than the average blood pressure of the control group. For the group with normal blood pressure who periodically worked overtime, their 24-hour blood pressure and heart rate increased only during the busy period. For the group with normal blood pressure, both systolic and diastolic blood pressure increased in the overtime subgroup. For the mildly hypertensive group, only the diastolic blood pressure was increased in the overtime subgroup. However, one caveat to the interpretation of these results is that these groups were measured at different times of the year, introducing the possibility of variability due to seasonal influences.

Iwasaki et al.'s study in salesmen also supports Hayashi et al.'s findings by demonstrating that overtime work hours increase blood pressure as well as heart rate. In their cross-sectional study of 71 salesmen in a machinery manufacturing company, Iwasaki et al. stratified the sample by age and number of work hours. On average, the men in the long working hours group worked 64.5 hours per week and the men in the shorter working hours group worked 57.2 hours per week. Iwasaki et al. found that the systolic blood pressure of the salesmen was significantly higher in the 50-60 year old age group working longer hours. The group that complained of greater fatigue (although fatigue was measured very crudely) had higher systolic blood pressure, leading the researchers to conclude that long work hours resulted in fatigue which in turn resulted in higher systolic blood pressure. Of note, although Iwasaki et al. did not find significant blood pressure increases associated with overtime hours in the younger age groups, the control group also worked comparatively long hours each week, which could explain the lack of an observed effect in the younger age groups. In a more recent study on a different population, emergency room residents, Fialho et al. (42) found that residents who worked a 24 hour continuous shift had abnormally high mean blood pressure readings as well as sleep diastolic blood pressure, compared to when the residents worked an eight hour day.

Some studies have found no association or a negative association between long work hours and hypertension (43). However, the study design and definitions of overtime hours varied by study. For example, Nakanishi et al. (44) found in their five-year prospective cohort study of Japanese white collar men that long work hours were negatively associated with the risk of hypertension, but this study had several limitations. These include the measurement of blood pressure only annually over a five year period, use of a standard sphygmomanometer, work hours measured subjectively by questionnaire, unknown overtime hour history, and lack of information about work hours during follow-up. In a cross-sectional study of 238 male engineers with blood pressure measurements taken on a single day, Park et al. (45) found that after controlling for age and sleep hours, there was an association between long work hours (defined as greater than 52 hours per week) and the low frequency component of heart rate variability, but no significant association between long work hours and blood pressure. However, blood pressure measurements in this study were only made twice during the day, after which the mean of the two readings was used in the statistical analysis.

Several mechanisms have been proposed to explain how long work hours can lead to their cardiovascular effects, including disruption of circadian rhythms (20) and greater sympathetic nervous system activity. In one study that examined the effects of sleep deprivation due to overtime work on blood pressure and heart rate variability in normotensive people, Tochikubo et al. (46) found that lack of sleep resulted in increased sympathetic nervous system activity the following day as measured by increased heart rate and blood pressure. However, the study sample was small (n=18) and male only. In another study which looked at insufficient sleep in patients who already had mild to moderate hypertension, Lusardi et al. (47) found that the subjects' blood pressure and heart rate increased significantly during the morning after sleep deprivation, and the subjects also had increased urinary excretion of norepinephrine during nights of sleep deprivation. However, the sample size was also small (n=36) with 20 men and 16 women. Based on these results, the authors suggest that lack of sleep results in increased sympathetic nervous system activity during the night and following morning which in turn increases heart rate and blood pressure. Both of these studies had interesting positive findings, but because their sample sizes were small and predominantly male, studies that use larger samples and include women are needed to explore how sleep deprivation due to overtime work affects sympathetic nervous system activity.

Ambulatory Blood Pressure Monitoring and Blood Pressure Measurement

The gold standard in the measurement of blood pressure has been the Korotkoff sound technique using a mercury sphygmomanometer by a doctor or other health care professional in the clinic setting. However, this method of blood pressure measurement is problematic and unreliable for several reasons: inaccuracies in the method of measurement, observer bias, the inherent variability of blood pressure, and the tendency for blood pressure for some people to increase in the presence of a physician ("white coat hypertension") (48). "White coat hypertension" refers to an acute elevation in a patient's blood pressure in response to the anxiety and stress of being in the doctor's office. This phenomenon is relatively benign but leads to a false positive diagnosis of hypertension and has low prognostic value, particularly in the prediction of cardiovascular risk (49). However, Belkic et al. (50) suggest a more ominous phenomenon, that of "occult hypertension in the workplace" in which measurements of casual blood pressure are normal in the clinic setting, but are high during work, and unlike "white coat hypertension", this phenomenon has significant diagnostic and prognostic implications.

Ambulatory blood pressure monitoring has undergone numerous technological advances that have enabled it to surpass casual office blood pressure measurements in both the diagnostic and prognostic evaluation of hypertension. The current generation of monitors are small, fairly easy to use, mechanically reliable, and reasonably accurate (51). As a result, the first major advantage of ambulatory blood pressure monitors over casual clinic blood pressure measurements is their reliability and accuracy, which is derived from repeated measurements, the ability to capture blood pressure variations over a 24-hour period, and removal of observer bias and the white coat effect, since measurements are made away from a medical environment (52). The ability of ambulatory blood pressure monitors to capture blood pressure fluctuations not only contributes to their accuracy, but also allows them to discover subtleties in blood pressure, such as the diurnal rhythm of blood pressure (48, 53).

Second, ambulatory blood pressure monitors are useful in the diagnosis of hypertension (54). For example, in a recent randomized controlled trial of antihypertensive treatment, Staessen et al. (55) found that ambulatory blood pressure monitoring as well as self-monitoring was useful in the diagnosis of white coat hypertension. In addition, ambulatory blood pressure monitoring is able to identify patients at risk who are not identified through casual clinic blood pressure readings (56), implying that casual clinic blood pressure readings are not sufficient in the identification of patients at risk for hypertension.

Third, ambulatory blood pressure monitoring holds prognostic significance by correlating better than casual clinic blood pressure with cardiovascular measures such as left ventricular mass (57-59), left ventricular function (60), and target organ damage (61), and very importantly, predicting cardiovascular risk in individual patients (62-64). In one of the first prospective studies on ambulatory blood pressure and cardiovascular risk, Perloff et al. (65) followed 1,076 patients recruited between 1962 and 1976 with essential hypertension and found that ambulatory blood pressure was a better predictor of cardiovascular risk than casual clinic blood pressure measurements and at the same time was an independent prognostic indicator in the participants' cardiovascular risk profile.

In a recent prospective study, Clement et al. (66) studied the association between ambulatory blood pressure and the development of cardiovascular events in 1,963 patients with treated hypertension with a median follow-up of 5 years and found that a higher ambulatory systolic or diastolic blood pressure was a significant independent predictor of cardiovascular events, even after adjustment for classic risk factors such as age, sex, smoking status, diabetes, cholesterol, body mass index, use of lipid lowering drugs, presence or absence of a history of cardiovascular events, and office measurement of blood pressure. In a different study population of 295 untreated hypertensive patients, Fagard et al. (67) recently studied the relationship between ambulatory blood pressure and clinic blood pressure after 6 months of follow-up, and the incidence of cardiovascular events in relation to these two pressures, and found that the baseline ambulatory blood pressure was a better predictor of cardiovascular events than the 6-month follow-up clinic blood pressure.

The disadvantages of ambulatory blood pressure monitoring include: measurements made in an uncontrolled setting, the introduction of unreliability if measurements were made on an atypical day, technical requirements, and cost. Since charges for ambulatory blood pressure monitoring range from $100 to $450, Appel and Stason (68) determined that on a societal level, ambulatory blood pressure monitoring would cost approximately $6 billion per year, assuming each of the estimated 50 million people with hypertension had one ambulatory monitoring test per year (at a cost of $120 per test). Currently, ambulatory blood pressure monitoring has limited usefulness as a clinical diagnostic tool, especially since the Centers for Medicare and

Medicaid Services, which sets federal reimbursement policies, has approved it only for the diagnosis of white-coat hypertension (69).

More research is still needed on the clinical significance of various aspects of ambulatory blood pressure measurements, including the cyclic components of 24-hour blood pressure variability, behavioral factors, the magnitude and speed at which blood pressure fluctuations occur, and assessment of the efficacy of antihypertensive drug treatment (70). Despite these limitations, ambulatory blood pressure monitoring is still much better suited than casual clinic blood pressure readings for the investigation of the effects of environmental exposures, various daily activities, psychological burden, and work home responsibilities on blood pressure (50), and for the purposes of the current study, the effects of overtime hours on blood pressure.

Shift Work and its Implications for the Effects of Overtime Work

Shift work has been studied more extensively than overtime work hours, but that body of research can provide insights into methodological approaches for studying the effects of overtime hours and the possible physiologic mechanisms by which overtime hours affect the cardiovascular system, since it shares some similarities and overtime hours can often be inextricably linked to shift work (24). Methodological issues in shift work research include selection bias, exposure classification, outcome classification, and the appropriateness of comparison groups. Some of the proposed mechanisms for shift work leading to the development of cardiovascular disease include: disruption of circadian rhythms (71), disturbed sociotemporal patterns, lack of social support, job stress (72), behaviors such as smoking (73), diet, alcohol consumption, and lack of exercise, and biochemical changes (e.g. cholesterol, triglycerides) (74, 75).

One of the few early prospective studies examining shift work and cardiovascular disease by Knutsson et al. (76) found the relative risk for cardiovascular disease in shift workers to be 1.4 times the risk for non-shift workers. Prior to this study was a 1972 prospective cohort study by Taylor and Pocock (77) using a national registry, but the study results were limited by the "healthy worker effect". Knutsson's 1986 study is methodologically one of the better studies on shift work and cardiovascular risk since older studies, which had reported negative findings had not controlled for age. Studies since then have controlled for age, especially since age is a major risk factor for cardiovascular disease. In the Helsinki Heart Study, which included males only, Tenkanen et al. (78) found a dose-response relationship between shift work and coronary heart disease: the relative risk for coronary heart disease increased with more adverse life-style risk factors (smoking, obesity, sedentary life style) in addition to shift work, even after controlling for socioeconomic status. Since the authors found a significant association despite the lack of rigorous measurement of blood pressure and the dichotomization of risk factor variables, the actual association between shift work and coronary heart disease may be stronger than that reported by the authors.

In a recent case-control study conducted in Sweden, Knutsson et al. (79) found an association between shift work and myocardial infarction. Interestingly, for participants in the 45-55 age group, the relative risk was 1.6 in men, but 3.0 in women. The results could not be explained by job strain, age, job education level, or smoking, and no interaction was found between job strain and shift work. However, socioeconomic status was not controlled for in this study and participants were classified as shift workers if they had completed shift work within the previous five years.

In a recent large prospective cohort study, Fujino et al. (80) found a significant association between rotating shift work and ischemic heart disease among Japanese male workers, with this association more pronounced in subjects who already had cardiovascular risk factors, including hypertension, obesity, habitual alcohol consumption, and smoking. The study included 17,649 men and asked participants which shift they had worked most regularly: day shift, rotating-shift, or fixed-night shift. While the rotating-shift workers had a higher risk of death from ischemic heart disease, this association was not found among fixed-night shift workers. Other recent prospective studies have also found an association between shift work and coronary heart disease (81-83). The mortality of the cohort in Karlsson's study (83) was monitored from 1952 to 2001 and the authors found that a longer duration of shiftwork (in years) was associated with an increased risk of mortality from coronary heart disease, with the greatest risk conferred to shiftworkers who had worked more than thirty years of shiftwork.

However, Inoue et al. (84) emphasize the importance of distinguishing among different job types of shift work and their associations with cardiovascular risk factors. In their study of male Japanese blue collar shift workers, Inoue et al. found a positive association between job type of shift work and hypertension, therefore suggesting that shift workers who work different types of jobs, particularly the amount of work-related physical activity, should not be combined together in studies on the effects of shift work on blood pressure.

To address the methodological problem of selection bias among shift workers or the "healthy worker effect", Kivimaki (85) examined whether shift workers with diabetes or cardiovascular disease were more likely to leave an organization or switch to day shifts. In their study of 7,037 female nurses working in 21 Finnish hospitals, Kivimaki found that nurses with diabetes or CVD were more likely to leave an organization regardless of the shift they worked and those risk factors did not predict a change from shift work to day work, leading the authors to conclude that selection out of shift work is unlikely to be a major source of bias in research on shift work and cardiovascular disease.

The majority of studies on shift work and cardiovascular disease have been conducted on men, since shift work is generally performed by men (e.g. firefighters, factory workers, taxi drivers, cooks, security guards) (86). The large number of female nurses is an exception, and therefore this occupational group in particular is an ideal one to study the effects of shift work in women. In a large prospective study on female nurses, the Nurses Health Study, Kawachi et al. (86) examined the association between shift work and coronary heart disease and found that even after controlling for coronary heart disease risk factors, 6 or more years of shift work resulted in a modest increase in coronary heart disease risk (relative risk of 1.51) in these nurses. Limitations of this study included lack of a detailed work history and nurses' current shift work status. However, a significant association was still found, so that the actual association between shift work and coronary heart disease could actually be greater than that reported by Kawachi et al.

Other shift work studies have produced contradictory results. In one British study, McNamee et al. (87) found that shift work did not increase the risk of ischemic heart disease, but shift work was defined broadly as having worked at least one month or more of shift work. Based on his prospective cohort study of males with a 4-year follow-up in Denmark, Tuchsen (88) raises the question of whether it is working nights or shifts that is the risk factor for developing ischemic heart disease. Using participants' documented occupation to determine their work hours and a national registry of hospitalizations, he found that working nights rather than shifts increased the risk of ischemic heart disease. However, limitations of the study include poor exposure information, since it was based on occupational group rather than individual data, and also possible misclassification of participants' occupations, since occupations were recoded only during one year of the 4 year study. In a study on healthy nurses, Munakata et al. (89) found that psychologic disturbances (decreased vigor and greater confusion) after night work were associated with altered cardiovascular and endocrine responses. Specifically, systolic blood pressure and heart rate were decreased during the night shift rather than the day shift, both the systolic and diastolic blood pressures were lower outside the hospital following the night shift, and plasma ACTH and cortisol were also lower after the night shift. However, this study had a very small sample size of 18 nurses with an average age of 29 so the results are difficult to generalize to a larger population. In their study on heart rate variability in male Japanese shift workers, Murata et al. (90) also found a selective reduction in sympathetic drive in the shift workers compared to the day workers.

To further complicate the issue, Yamasaki et al. adds the dimension of race as well as working nights in the association between shift work and cardiovascular disease. In a study on nurses (the same study sample as our current study), Yamasaki et al. (91) found that nurses who worked the evening/night shift or were African-American were significantly more likely to be "nondippers" (less than 10% drop in systolic blood pressure during sleep) in their diurnal blood pressure rhythm. Nurses who worked the evening/night shift were 6.1 times more likely and African-American nurses were 7.1 times more likely than day shift workers to be nondippers.

The research on the effects of shift work on hypertension also shares similarities to the research on overtime work hours and hypertension. In one Japanese study, Ohira et al. (92) demonstrated that shift workers had a greater increase in their blood pressure, heart rate variability, and long-term blood pressure than day workers. However, this study had several limitations, including a small sample size (n=53), male participants only, different types of jobs for the day and shift workers, longer hours worked per shift by the shift workers than the day workers, although the total number of hours per week were the same, and finally, shorter sleep time per night for the shift workers than the day workers, which could be an alternate cause for greater sympathetic nervous system activity and higher blood pressure in the shift workers. Despite these limitations, Ohira et al. still reported a blood pressure increase in shift workers, suggesting that further standardized studies should be undertaken to explore whether the association between shift work and hypertension is actually greater than that reported by the authors.

In a prospective cohort study of Japanese male workers with a 5-year follow-up, Morikawa et al. (93) also found an association between shift work and elevated blood pressure. In their study on manual workers who worked rotating shifts, Morikawa et al. found that within the younger age group, the relative risk for hypertension was increased in the rotating shift workers compared to the day workers. For the older age group, the relative risk for hypertension was increased if the workers converted from a rotating shift schedule to day work rather than staying on a day work or shift work schedule. Despite its study limitations, such as including males only, health exams occurring only annually over the 5-year follow-up period, blood pressure measured only at these annual health exams with a sphygmanometer, and the introduction of bias due to lack of information regarding the participants who were lost to follow-up after resignation from the company for unknown reasons, the study found a significant association between shift work and elevated blood pressure. For shift workers who already have hypertension, shift work can contribute to the progression from mild to severe hypertension. In Oishi et al.'s (94) cohort study of 6495 Japanese male workers, shift work was found to be a risk factor in the progression of hypertensive disease. These studies demonstrate the need for further studies, particularly in women, to determine the strength of the association between shift work and elevated blood pressure.

Overtime Hours, Women and Nurses

The previous summary of the research demonstrates that overtime work can be associated with cardiovascular disease and hypertension, but this association has not been studied as extensively in women as in men. However, it has been suggested that women can be at increased risk for the health effects of overtime work because of their additional domestic responsibilities (23). One study by Galambos and Walters (95) reveals the importance of adding the number of hours spent fulfilling domestic responsibilities in the calculation of work hours to determine its effects. They found that in households with dual-earner spouses, long work hours and inflexible schedules for the husband resulted in stress in the husbands, but not wives, whereas long work hours in the wives resulted in role strain in the wives as well as anxiety and depression in the husband.

Nurses are a particularly suitable occupational group for long work hours research, especially given the current climate for hospitals and the nursing workforce. Nursing in the 1990s underwent a crisis due to systemic understaffing and shortages. In March 2001, there were approximately 2.7 million registered nurses (RNs) in the United States (96). While the demand for nurses is expected to grow over the first twenty years of the 21st century, the total number of full-time registered nurses is expected to peak around 2007 and subsequently decline so that by 2020, the supply of nurses will be nearly 20% below the projected workforce requirements (97). In a retrospective cohort analysis of employment trends, Buerhaus et al. (97)

found that the average age of working registered nurses increased by 4.5 years between 1983 and 1998 and within the next 10 years, the average age will be 45.4 years. The older average age of nurses reflects two phenomena: the largest cohort of nurses in the future will be between 50 and 69 years of age and more importantly, there has been a decline in the number of younger women choosing nursing as a career. In 1980, 40% of the nurses were age 35 or younger, and now 18% belong to that cohort.

The nursing shortage and chronic understaffing have contributed to longer work hours, greater stress, chronic fatigue and work-related injuries in the nurses . Female nurses also face the burden of meeting domestic responsibilities in addition to the hours they work at their job. Buerhaus (98) found that male registered nurses, nonwhite registered nurses, and registered nurses with associate degrees were more likely to work longer hours than registered nurses with young children at home. Previous research on shift work in nurses has found poorer job performance and higher job stress in nurses working rotating shifts versus day shifts (99), lower job satisfaction and higher job stress in nurses working longer shifts (12 hours versus 8 or 10 hour shifts) (100), and a greater risk for substance abuse in nurses working longer night shifts (greater than 8 hours) and rotating shifts (18). Research on the cardiovascular effects of work hours in nurses has usually been on aspects of shift work (Kawachi et al. (86), Munakata et al. (89), Yamasaki et al. (91)) and there has been very limited research on the effects of overtime work hours in nurses. More generally, most of the research to date on the cardiovascular effects of long work hours have been conducted in men and there have been very few prospective studies using objective measures of blood pressure and work hours.

Study Hypotheses

The objective of our study is to examine the association between overtime hours, shift worked and ambulatory blood pressure (ABP) among female nurses and nurses' aides. We hypothesize that ambulatory blood pressure is positively associated with work hours on the day the ambulatory blood pressure monitor was worn, during the 2-week period of ambulatory blood pressure monitoring and during the 2-4 weeks immediately prior to the ambulatory blood pressure monitoring. We also hypothesize that nurses and nurses' aides working an evening or night shift will have higher ABP than nurses working a day shift, controlling for hours worked on the shift.

METHODS

Study Sample

The sample consists of 97 female nursing staff (registered nurses, licensed practical nurses, and nurse aides) from a New York City hospital who participated in the New York City Work Site Blood Pressure Study, a prospective cohort study, in 1995 (Wave 3) and 73 who were re-evaluated in 1999-2000 (Wave 4). The Study began in 1985 (Wave 1) as a case-control study of 215 men at 7 sites in New York City to investigate the relationship of work stress to hypertension and ambulatory blood pressure. The original study is described in detail elsewhere (101-104). The nursing staff were included in the study in 1995.

The study sample selection process for the nurses has been described by Yamasaki et al. and Kario et al. (91, 105). At Wave 3, in 1995, blood pressure screening was conducted on 727 of the 764 nursing staff of the medical/surgery, child/maternity, and critical care departments. After the initial screening, 232 nurses were eligible for the study. Eligibility criteria were: aged 30-60 years, employed full-time at the hospital for at least 1 year, able to speak and read English, body mass index less than 30 kg/m^2, and a screening blood pressure less than 160/105 mm Hg. Exclusion criteria were: taking antihypertensive medications or medications affecting blood pressure, evidence of cardiovascular disease based on self-report and/or an electrocardiogram, history of secondary hypertension or renal disease, working a second job for at least 15 hours per week, and pregnancy (91).

The 232 nurses were then stratified into 7 groups to ensure comparable representation of nurse aides and nurses over 40 years old who would have been underrepresented without stratification. One stratum was composed of nurse aides and licensed practical nurses, and the remaining 6 strata were composed of registered nurses. The registered nurses were subdivided into the 6 strata by 10-year cohorts and the shift they worked (day versus evening/night). From this group, a total of 166 nurses were invited to participate in the study, with 105 participants (99 women and 6 men) ultimately completing the protocol (63%). Written informed consent was obtained for all participants. Two of the 99 female nurses later withdrew (one after termination from her job, the other chose not to complete the psychosocial questionnaire or undergo the cardiovascular diagnostic exam), resulting in 97 female nurses participating in the study in 1995.

Yamasaki et al. (91) found that in comparison to the 61 eligible subjects who chose not to participate in the study, the 105 participants (99 women and 6 men) who completed the protocol did not differ significantly with respect to age, length of employment, height, arm circumference, screening diastolic blood pressure, race/ethnic group, and having been born in the United States. The participants differed slightly from the non-participants in educational level (non-participants had 0.4 years more education [p=0.07]), screening systolic blood pressure (participant blood pressures were 2.6 mm Hg lower [p=0.09]), work shift (evening shift workers were overrepresented due to stratified sampling [p=0.12], but this difference was not significant after evening and night shift workers were combined), and job title (nurse aides and licensed practical nurses were slightly overrepresented due to stratified sampling [p=0.12]). The only two variables that differed significantly ($p<0.05$) between participants and non-participants were BMI (participants were 6 lbs heavier, p=0.04) and marital status (participants were more likely to be single/divorced (p=0.05).

In 2000 (Wave 4), 73 of the 97 nurses were re-evaluated and wore an ambulatory blood pressure monitor. 61 of the nurses met all the criteria to be included in the overtime work hours data analysis: they participated in the study at Wave 3, continued to work at the New York City hospital in 1999-2000, and thus had work hours data available. While additional nurses participated at Wave 4, they had left the New York City hospital to work for other employers. In the interim between 1995 and 2000, the New York City hospital underwent organizational restructuring. Of the 36 nursing staff who did not participate in 1999-2000, 26 were no longer full-time employees at this hospital, 9 chose only to answer a brief questionnaire, and one completed the full protocol but chose not to wear the ambulatory blood pressure monitor because of her multiple sclerosis.

Blood Pressure Measurement

The study participants wore ambulatory blood pressure monitors (SpaceLabs 90207) for a 24-hour period, including a work shift, in 1995 and 1999-2000. A blood pressure cuff was initially placed on the participants' non-dominant arm and calibrated five times against a standard mercury sphygmomanometer (averages had to be within 5 mm Hg of each other to be considered in concordance with each other) by a technician. Throughout the 24-hour period, blood pressure readings were recorded every 15 minutes. The readings were divided into work, home and sleep time based on the information provided in the participants' diary entries in which they recorded their activity, posture, location, and mood. A minimum of 5 blood pressure recordings at each location (work, home, and sleep) were required for participants to be included in the analysis for each location. For statistical analyses, mean ambulatory blood pressure readings were computed for the six different combinations of location and type of blood pressure: work systolic and diastolic pressure, home systolic and diastolic pressure, and sleep systolic and diastolic pressure.

Work Hours

The hospital provided work hour records by two-week pay periods for the six-month period prior to and during the measurement of the participants' ambulatory blood pressure in 1995 and 2000. Shift work data was obtained for the day the nurses wore the monitors in 1995 and 2000. For purposes of analysis, the work hour data was divided into 8 different time periods: the two-week period the ambulatory monitor was worn, 2 weeks before the ambulatory monitor was worn, 4 weeks before, 2 months before, 3 months before, 4 months before, 5 months before, and 6 months before the ambulatory monitor was worn. "Overtime" was defined in this study as any time worked over the standard work week of 37.5 hours . Shift work on the day the monitor was worn was categorized as day, evening, or night, and varied in length, with each shift lasting 8, 10, or 12 hours. The work shifts were as follows: day shift (7AM-7PM or 8AM-4PM), evening shift (4PM-12AM), and night shift (7PM-7AM or 11PM-7AM).

Measurement of Other Variables

Participants underwent a medical examination and completed multiple questionnaires (106). Variables measured included: occupational status, educational level, marital status, leisure time physical exercise, BMI, smoking, alcohol, job physical exertion, as well as variables related to job characteristics, including job demands, job decision latitude and job strain. The nurses had one of three occupational categories: registered nurse, licensed practical nurse, and nurse aide. Educational level was determined from a questionnaire and measured as total years of education. Marital status was categorized as: married; divorced or separated; or never married. Leisure time physical exercise was ascertained from a questionnaire with the following question: "Do you exercise pretty regularly at the present time?" During the medical examination, height and weight intake was completed and BMI was calculated using the following formula: weight (kg)/height (m^2). Alcohol and smoking behavior were determined by questionnaire. Alcohol consumption was ascertained by two questions measuring frequency and quantity of intake. Regular drinking was defined as binge drinking or drinking greater than or equal to 4-6 days per week. The three-year test-retest reliability using kappa was 0.55 ($p<.001$). Current smoking status was determined by the question: "Do you now smoke cigarettes?" The three-year test-retest reliability using kappa was 0.69 ($p<.001$)(106)(7).

The nurses also completed the Job Content Questionnaire (JCQ) which measured job characteristics and has been previously validated in other studies (107, 108). Job demands was defined by five items: excessive work, conflicting demands, insufficient time to do the work, work fast, and work hard. Internal consistency reliability was 0.71 (Cronbach's alpha). Job decision latitude was calculated by the sum of two subscales: skill utilization (consisting of six items: keep learning new things, can develop skills, job requires skill, job involves task variety, job is repetitious (reverse scored), and job requires creativity) and decision authority (consisting of three items: have freedom to make decision, can choose how to perform the work, have a lot of say on the job). The internal consistency reliability was 0.71 (Cronbach's alpha) for the decision latitude scale (sum of skill utilization and decision authority subscales). Job strain was defined as job demands greater than the study sample median combined with job decision latitude less than the sample median (a dichotomous variable).

Statistical Analysis

Cross-sectional data analysis was completed for both Wave 3 and Wave 4 using SPSS 12.0 and 13.0. Multiple regression analyses were conducted separately for each of the 6 blood pressure variables as dependent variables and for 3 of the overtime work periods (derived from employer records) as independent variables, that is, during the 2-week period the ambulatory monitor was worn, 2 weeks before the monitor was worn, and 4 weeks before the monitor was worn in 1995 and 2000. In addition, hours worked on the day the monitor was worn and shift worked (self-reported data) were examined as independent variables. All regression models controlled for age on the first step. On the second step, models examining shift worked included control for hours worked on the day the monitor was worn. Similarly, models examining hours worked on the day the monitor was worn included control for shift worked. On the third step, race, and body mass index were included.

Finally, the backwards elimination method was used to control for potential confounders in addition to shift worked, age, race, and body mass index. This method was chosen because of the small sample size and large number of potential confounders. The backwards elimination method allowed for the inclusion of all independent variables in the equation and removal of insignificant variables one-by-one using the conservative criterion of $p > 0.20$. The following covariates were removed from the final model if the p-value of their coefficient was >0.20: education, smoking, alcohol, job physical exertion, leisure-time exercise, occupational status and marital status. The overtime work hour data and shift work data were analyzed both at Wave 3 and Wave 4 for all nurses and registered nurses only, because of the large number of registered nurses in the sample.

In post-hoc analyses, a third sub-group, nurses with valid home blood pressure readings, was analyzed at Wave 3 and Wave 4. Two sets of cohorts were analyzed with valid home blood pressure readings: all nurses with valid Wave 4 home blood pressure readings (n=47) and registered nurses only with valid Wave 4 home blood pressure readings (n=37). This analysis of nurses with valid home blood pressure readings was undertaken after it was determined that there were fewer nurses with home blood pressure readings than work or sleep blood pressure readings at Wave 4 and the association between overtime work hours and blood pressure was found to be stronger for nurses with valid home blood pressure readings than for all nurses who had participated at Wave 4. Correlations were computed for the restricted sample (n=47 for all nurses, n=37 for registered nurses only) to determine whether the correlations were consistent across work, home and sleep blood pressures and whether the nurses with valid home blood pressure readings were different in some way from the nurses with valid work or sleep blood pressure readings.

In other post-hoc analyses, we examined the interaction between past overtime hours (for Wave 4), hours worked on the day the monitor was worn (for Waves 3 and 4) and a known risk factor for blood pressure elevation, job strain. We stratified the 61 nurses who participated at Wave 4 by those who reported job strain (n=25) and those with no reported job strain (n=36), and the 85 nurses who participated at Wave 3 by those who reported job strain (n=35) and those with no reported job strain (n=50). We then created a new job strain–work hours interaction variable by multiplying job strain by the work hour variable of interest. The new interaction term was added as the last step of the regression analysis after the backwards elimination method was completed.

RESULTS

Sample Characteristics

Descriptive statistics for the sample of 97 female nurses at Wave 3 (1995) and the 61 nurses who also participated at Wave 4 (1999-2000) and had work hour data available from their employer are shown below in **Table 1**. The average age of all nurses who participated at Wave 3 was 40.3 years (range 30 to 59 years). Of the 97 nurses who participated in the study at Wave 3, 73 nurses were re-evaluated and wore an ambulatory blood pressure monitor at Wave 4 in 1999-2000. 61 nurses met all the criteria at Wave 4 to be included in the overtime work hour data analysis: they participated in the study at Wave 4, continued to work at the New York City hospital in 1999-2000, and thus had work hour data available. Four nurses participated at Wave 4 and wore an ambulatory blood pressure monitor, but had left the New York City hospital to work for other employers and thus did not have available official work hour data.

The 36 nurses who participated at Wave 3 only and the 61 nurses who participated at both time periods and had work hour data available are compared below in Table 1. There were no significant differences between the two groups during Wave 3, thus no evidence of selective attrition. Table 1 also compares the 61 nurses who participated during both time periods at Wave 3 and Wave 4. There were statistically significant increases within the group of 61 nurses between the two time periods with regards to education, body mass index, work, home and sleep systolic and diastolic blood pressure.

Table 1. Comparison of Cohort Sample of Nurses at Wave 3 who Participated at Wave 3 but Not Wave 4 (n=36), and Nurses who Participated at Both Wave 3 and Wave 4 at Wave 3 (n=61) and Wave 4 (n=61)

Variable	WAVE 3 but not WAVE 4[a] (n=36)		WAVE 3[b] (n=61)		WAVE 4[c] (n=61)
	Mean (SD)	p[d]	Mean (SD)	p[e]	Mean (SD)
Age (years)	39.5 (7.4)		40.7 (7.4)	***	45.5 (7.6)
Education (years)	15.3 (2.4)		15.2 (1.9)	*	15.6 (1.6)
BMI (kg/m^2)	24.4 (3.7)		24.5 (3.1)	***	26.1 (3.7)
Work ABP					
Systolic (mm Hg)	116.4 (7.5)		117.2 (9.4)	***	121.5 (10.7)
Diastolic (mm Hg)	77.1 (6.3)		77.2 (6.8)	**	79.2 (7.5)
Home ABP					
Systolic (mm Hg)	113.9 (9.5)		115.1 (9.6)	***	120.4 (12.8)
Diastolic (mm Hg)	73.8 (6.7)		74.2 (7.6)	*	76.2 (8.2)
Sleep ABP					
Systolic (mm Hg)	99.5 (6.8)		103.1 (10.6)	**	106.7 (9.8)
Diastolic (mm Hg)	59.7 (5.9)		61.5 (7.5)		62.8 (6.4)
	%		%		%
Race/Ethnicity					
White	33.3%		44.3%		---[f]
Black	41.7%		34.4%		---
Asian	16.7%		19.7%		---
Hispanic	8.3%		1.6%		---
Occupational Status					
Nurses Aide	11.1%		8.2%		6.6%
LPN	11.1%		11.5%		13.1%
RN	77.8%		80.3%		80.3%
Marital Status					
Married	44.4%		47.5%		52.5%
Div/Sep	36.1%		16.4%		19.7%
Never Married	19.4%		34.4%		27.9%
Current Smoker	19.4%		11.5%		13.1%
Regular drinker	13.9%		8.2%		9.8%

NOTES:

*p< .05; **p< .01; ***p< .001.

[a]. For subjects at Wave 3 who only participated at Wave 3 but not Wave 4: home ambulatory blood pressure (n=34) and sleep ambulatory blood pressure (n=35).

[b]. For subjects at Wave 3 who participated at both Wave 3 and 4: home and sleep ABP (n=60).

[c]. For subjects at Wave 4 who participated at both Wave 3 and 4: home ambulatory blood pressure (n=47) and sleep ambulatory blood pressure (n=56).

[d]. p-value of the significance test (independent samples t-test for age, education, BMI, work ambulatory blood pressure and chi-square test for race, occupational status, marital status, smoking and alcohol use) for the difference at Wave 3 between nurses who participated only at Wave 3 (n=36) and nurses who participated at both Wave 3 and Wave 4 (n=61).

[e]. p-value of the significance test (paired t-test for age, education, BMI, work ambulatory blood pressure; McNemar's chi-square test for smoking and alcohol use; Kendall's W test for occupational status and marital status) for the change in variables between Wave 3 and Wave 4 for the nurses who participated at both Wave 3 and Wave 4 (n=61).

[f]. Race was not measured at Wave 4.

The number of overtime hours worked per week (>37.5 hours) during the 2-week pay period the monitor was worn in 1995 and 2000 are described in **Figure 1** below. 56% of participants in 1995 and 60.7% of participants in 2000 did not work any overtime hours during the 2-week period the monitor was worn. The mean number of overtime hours in 1995 during the 2-week period the monitor was worn was 1.97 hours per week (standard deviation 3.34 hours per week) and in 2000 was 2.34 hours per week (standard deviation 4.15 hours per week). **Table 2** presents mean overtime hours worked per week in 1995 and 2000 for the 3 work periods included in the statistical analysis and **Table 3** describes the variety of shift schedules and lengths of shifts worked by the nurses in 1995 and 2000. The actual shift times were previously described in the Methods section.

Figure 1. Overtime Hours per Week (>37.5 hours) During the Two Week Pay Period that the Ambulatory Monitor was Worn

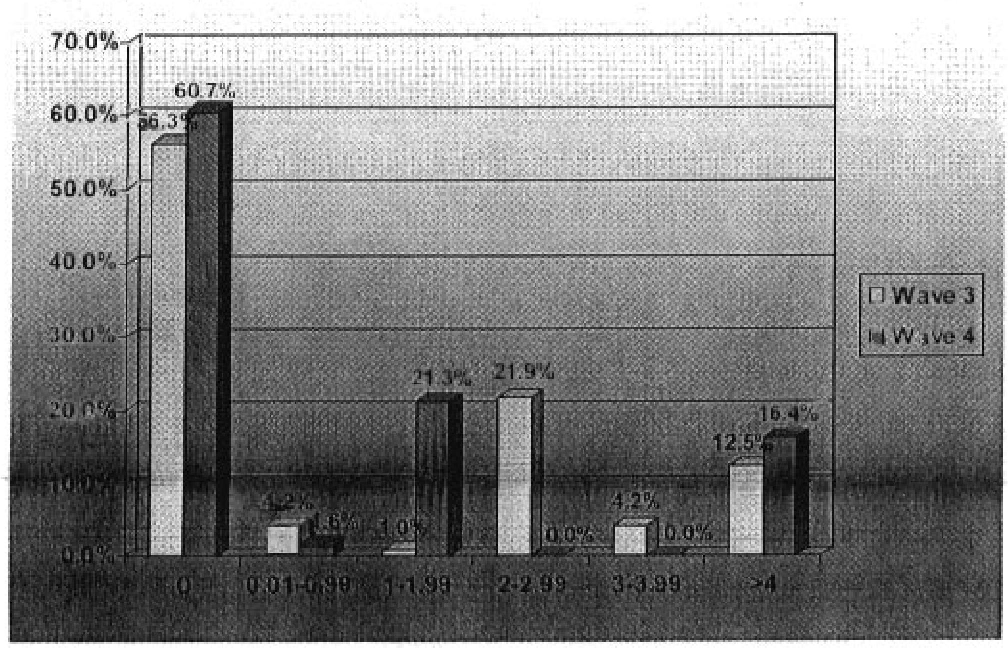


Table 2. Mean Overtime Hours Worked per Week in 1995 and 2000 for All Nurses (based on employer data from 2 week pay periods)

Wave 3	N	Mean	Standard Deviation
2 weeks including ABP measurement	96	1.97	3.34
2 weeks before ABP period	96	2.05	4.39
1 month before ABP period	96	1.11	3.12

Wave 4	N	Mean	Standard Deviation
2 weeks including ABP measurement	61	2.34	4.15
2 weeks before ABP period	61	1.95	4.02
1 month before ABP period	60	1.14	3.13

Table 3. Number of Hours Worked on Shift and Shift Worked by Occupational Status on the Day the Monitor was Worn in 1995 and 2000

1995

		SHIFT CHARACTERISTICS		
JOB TITLE	TOTAL N	SCHEDULE	LENGTH (Hrs)	N
Nurses' Aide	7	Day	8	2
		Evening	8	4
		Night	8	1
Licensed Practical Nurse	7	Day	12	5
		Evening	8	1
		Night	12	1
RN	71	Day	8	5
			10	7
			12	34
		Evening	8	2
			10	3
		Night	8	4
			12	16

2000

		SHIFT CHARACTERISTICS		
JOB TITLE	TOTAL N	SCHEDULE	LENGTH (Hrs)	N
Nurses' Aide + Non-hospital clerks	8	Day	8	6
		Evening	8	2
Licensed Practical Nurse	8	Day	12	6
		Night	12	2
RN	57	Day	8	8
			12	25
		Evening	8	4
		Night	12	20

Overtime hours during these 2-week periods were positively correlated with age, negatively associated with occupational status (i.e. nurse aides worked longer hours than licensed practical nurses and registered nurses), and were mixed for body mass index, education and exercise (see **Table 4**).

Table 4. Correlations between Overtime Hours and Occupational Status, Age, Education, BMI, and Regular Exercise

Wave 3

	Age			Education			Body Mass Index		
	N	r	p	N	r	p	N	r	p
Hours worked the day monitor was worn	85	-0.29	0.01	85	0.15	0.17	85	-0.10	0.36
2 weeks including ABP measurement	91	0.00	0.99	91	0.00	1.00	91	-0.01	0.96
2 weeks before ABP period	91	0.04	0.72	91	-0.13	0.22	91	-0.01	0.94
1 month before ABP period	91	0.07	0.50	91	-0.05	0.62	91	-0.09	0.41

	Regular Exercise					
	Yes		No		t	p
	N	mean	N	mean		
Hours worked the day monitor was worn	23	11.04	61	10.85	-0.47	0.64
2 weeks including ABP measurement	23	1.31	67	2.17	1.08	0.28
2 weeks before ABP period	23	1.18	67	2.20	1.43	0.16
1 month before ABP period	23	0.80	67	1.00	0.29	0.77

	Occupational Status							
	RN		LPN		Nurse Aide		F	p
	N	mean	N	mean	N	mean		
Hours worked the day monitor was worn	71	11.10	7	11.43	7	8.00	15.15	0.00
2 weeks including ABP measurement	73	1.86	9	1.89	9	2.50	0.15	0.86
2 weeks before ABP period	73	1.57	9	2.50	9	4.17	1.59	0.21
1 month before ABP period	73	0.68	9	0.61	9	3.35	4.29	0.02

Wave 4

	Age			Education			Body Mass Index		
	N	r	p	N	r	p	N	r	p
Hours worked the day monitor was worn	73	-0.30	0.01	73	-0.04	0.75	73	0.06	0.64
2 weeks including ABP measurement	61	0.17	0.20	61	0.02	0.85	61	0.14	0.27
2 weeks before ABP period	61	0.14	0.27	61	-0.03	0.85	61	0.09	0.48
1 month before ABP period	60	0.16	0.22	61	-0.09	0.50	60	0.15	0.25

	Regular Exercise					
	Yes		No		t	p
	N	mean	N	mean		
Hours worked the day monitor was worn	21	10.29	52	11.15	1.74	0.09
2 weeks including ABP measurement	17	2.41	44	2.31	-0.09	0.93
2 weeks before ABP period	17	1.73	44	2.03	0.26	0.80
1 month before ABP period	17	1.49	43	1.00	-0.54	0.59

	Occupational Status							
	RN		LPN		Nurse Aide*		F	p
	N	mean	N	mean	N	mean		
Hours worked the day monitor was worn	57	11.16	8	12.00	8	8.00	18.65	0.00
2 weeks including ABP measurement	49	2.18	8	3.53	4	1.88	0.38	0.68
2 weeks before ABP period	49	2.31	8	0.69	4	0.00	1.06	0.35
1 month before ABP period	49	1.13	7	1.61	4	0.47	0.17	0.85

***Note**: For Hours worked the day monitor was worn at Wave 4, Nurse Aide category includes 4 Nurse aides and 4 Non-hospital clerks.

Associations Between Overtime Hours during 2-Week Pay Periods and Ambulatory Blood Pressure

Multiple regression analyses using the backwards elimination method were conducted to determine associations between blood pressure and overtime worked during three time periods (the 2-week period the blood pressure monitor was worn, 2 weeks before, and 1 month before the monitor was worn). **Table 5** presents the results of regression analyses for all nurses and **Table 6** for registered nurses only.

Table 5. Association between Overtime Work Hours during 2-week Pay Periods and Ambulatory Blood Pressure (ABP) for All Nurses

Wave 3 (n=85), 1995

Associations with:	Work Ambulatory SBP			Home Ambulatory SBP			Sleep Ambulatory SBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	85	-0.301	0.296	83	-0.067	0.817	84	0.266	0.351
2 week pay period before ABP measurement	85	-0.095	0.671	83	0.142	0.524	84	0.249	0.274
1 month before ABP measurement	85	-0.484	0.172	83	0.219	0.554	84	0.370	0.322

Associations with:	Work Ambulatory DBP			Home Ambulatory DBP			Sleep Ambulatory DBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	85	-0.255	0.242	83	-0.156	0.520	84	0.197	0.350
2 week pay period before ABP measurement	85	-0.008	0.961	83	0.18	0.324	84	0.271	0.090
1 month before ABP measurement	85	-0.35	0.189	83	0.601	0.039	84	0.261	0.309

Note: Coefficient B represents the estimated increase in blood pressure (mmHg) associated with each additional hour of overtime worked.

Wave 4 (n=61), 2000

Associations with:	Work Ambulatory SBP			Home Ambulatory SBP			Sleep Ambulatory SBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	61	0.045	0.904	47	0.441	0.347	56	-0.312	0.379
2 week pay period before ABP measurement	61	0.208	0.566	47	0.886	0.089	56	0.404	0.201
1 month before ABP measurement	60	-0.286	0.536	46	0.690	0.417	55	0.167	0.684

Associations with:	Work Ambulatory DBP			Home Ambulatory DBP			Sleep Ambulatory DBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	61	-0.072	0.778	47	0.019	0.953	56	-0.200	0.395
2 week pay period before ABP measurement	61	-0.244	0.327	47	0.191	0.598	56	0.058	0.786
1 month before ABP measurement	60	-0.604	0.051	46	-0.199	0.728	55	-0.081	0.771

Note: Coefficient B represents the estimated increase in blood pressure (mmHg) associated with each additional hour of overtime worked.

Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Table 6. Association between Overtime Work Hours during 2-week Pay Periods and Ambulatory Blood Pressure (ABP) for Registered Nurses Only

Wave 3 (n=71), 1995

Associations with:	Work Ambulatory SBP			Home Ambulatory SBP			Sleep Ambulatory SBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	71	-0.054	0.866	70	-0.242	0.482	70	0.046	0.891
2 week pay period before ABP measurement	71	-0.023	0.929	70	-0.048	0.861	70	0.109	0.697
1 month before ABP measurement	71	-0.472	0.435	70	-0.351	0.580	70	0.413	0.523

Associations with:	Work Ambulatory DBP			Home Ambulatory DBP			Sleep Ambulatory DBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	71	-0.117	0.642	70	-0.360	0.165	70	0.116	0.647
2 week pay period before ABP measurement	71	0.005	0.979	70	-0.091	0.660	70	0.368	0.062
1 month before ABP measurement	71	-0.280	0.551	70	-0.172	0.726	70	0.728	0.123

Note: Coefficient B represents the estimated increase in blood pressure (mmHg) associated with each additional hour of overtime worked.

Wave 4 (n=49), 2000

Associations with:	Work Ambulatory SBP			Home Ambulatory SBP			Sleep Ambulatory SBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	49	0.005	0.991	37	-0.257	0.627	45	-0.462	0.268
2 week pay period before ABP measurement	49	0.206	0.602	37	0.808	0.127	45	0.320	0.362
1 month before ABP measurement	49	-0.476	0.343	37	-0.216	0.828	45	0.081	0.860

Associations with:	Work Ambulatory DBP			Home Ambulatory DBP			Sleep Ambulatory DBP		
	N	B	p	N	B	p	N	B	p
2 week pay period including ABP measurement	49	0.056	0.855	37	-0.039	0.924	45	-0.162	0.566
2 week pay period before ABP measurement	49	-0.203	0.452	37	0.227	0.586	45	0.098	0.681
1 month before ABP measurement	49	-0.644	0.057	37	0.021	0.978	45	-0.025	0.934

Note: Coefficient B represents the estimated increase in blood pressure (mmHg) associated with each additional hour of overtime worked.

Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Overtime hours in the one month before the monitor was worn was significantly associated with home diastolic ABP, a magnitude of +0.6 mm Hg for each overtime hour worked (p=.039). Three additional associations were positive and below the $p<0.10$ level of significance. However, given that 36 tests of association were conducted, it is possible that these positive associations could have arisen solely due to chance. Also, non-significant findings were not solely due to small sample size. Sixteen of the 36 regression coefficients, listed in **Table 5**, were not in the expected direction. Similar results were observed when restricting the sample to RNs only (**Table 6**); there were no significant positive associations, and only two associations below the $p<0.10$ level.

Associations Between Work Hours on the Day the ABP Monitor was Worn and Ambulatory Blood Pressure

Table 7 presents associations between work hours on the day the ABP monitor was worn and ambulatory blood pressure (ABP). Significant positive associations were found between hours worked on the day the monitor was worn and work, home and sleep systolic blood pressure as well as home diastolic blood pressure at Wave 4. Associations for work and sleep diastolic blood pressure were in the expected direction but did not reach the $p<.05$ level of significance. On the other hand, positive associations were not observed at Wave 3. In fact, at Wave 3, 2 of 6 associations (controlling for age only) were significant ($p<.10$) and not in the expected direction – that is, greater work hours were associated with lower blood pressure. However, after controlling for shift worked and other potential confounders, these associations were no longer statistically significant.

The magnitudes of associations at Wave 4 were substantial. Twelve-hour shift workers' ABP was 4-19 mm Hg systolic and 3-8 mm Hg diastolic greater than 8-hour shift workers' systolic and diastolic ABP, respectively (**Figure 2**). Restricting the samples to RNs only slightly reduced these effect estimates.

Table 7. Associations between Hours Worked on the Day the Monitor was Worn and Ambulatory Blood Pressure

Wave 3 (n=85)

	Work SBP			Home SBP			Sleep SBP		
	N	B	p	N	B	p		B	p
Hours Worked, controlling for age only	85	-0.801	0.186	83	-0.226	0.721	84	-0.9	0.174
Hours Worked, controlling for shift, age		-0.588	0.392		0.453	0.516		-0.101	0.889
Hours Worked, controlling for all variables		-0.63	0.353		0.412	0.552		-0.676	0.359

	Work DBP			Home DBP			Sleep DBP		
	N	B	p	N	B	p		B	p
Hours Worked, controlling for age	85	-0.871	0.054	83	0.049	0.92	84	-0.966	0.035
Hours Worked, controlling for shift, age		-0.806	0.117		0.414	0.45		-0.510	0.319
Hours Worked, controlling for all variables		-0.735	0.15		0.623	0.313		-0.655	0.195

Note: Coefficient B represents the estimated increase in blood pressure (mmHg) associated with each additional hour of overtime worked.

Wave 4 (n=73)

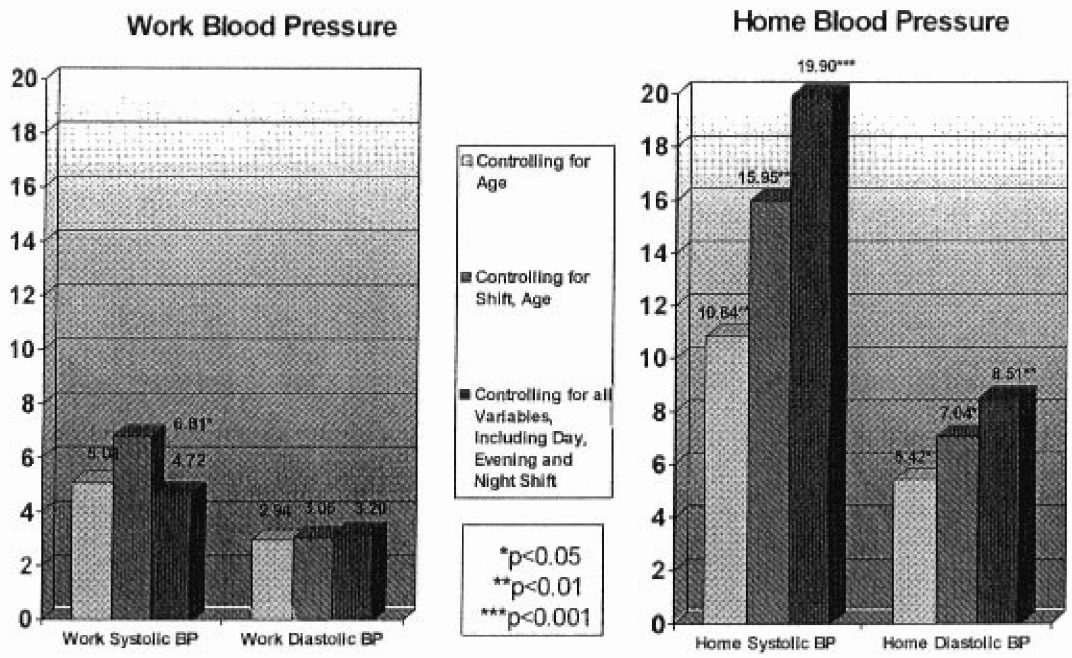
	Work SBP			Home SBP			Sleep SBP		
	N	B	p	N	B	p		B	p
Hours Worked, controlling for age	73	1.269	0.083	57	2.709	0.003	67	1.481	0.032
Hours Worked, controlling for shift, age		1.702	0.053		3.988	0.000		2.085	0.012
Hours Worked, controlling for all variables		1.180	0.201		4.976	0.000		1.167	0.159

	Work DBP			Home DBP			Sleep DBP		
	N	B	p	N	B	p		B	p
Hours Worked, controlling for age	73	0.735	0.159	57	1.356	0.026	67	0.589	0.189
Hours Worked, controlling for shift, age		0.762	0.225		1.760	0.015		0.748	0.167
Hours Worked, controlling for all variables		0.801	0.255		2.127	0.006		0.232	0.673

Note: Coefficient B represents the estimated increase in blood pressure (mmHg) associated with each additional hour of overtime worked.

Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Figure 2. Blood Pressure of 12-hour Shift Workers (vs. 8-hour Shift Workers) on the Day the Monitor was Worn



Associations Between Shift Worked and Ambulatory Blood Pressure

Nurses who worked the evening shift (versus the day shift) had substantially higher elevations in work, home, and sleep ambulatory blood pressures (ranging from 0.05 to 15.6 mm Hg systolic and -1.3 to 6.3 diastolic) in both 1995 and 2000, associations which reached statistical significance for home blood pressure (see **Table 8** and **Figure 3**). Nurses who worked the night (versus day) shift did not have substantially or significantly higher ambulatory blood pressures than workers on day shifts.

Table 8. Blood Pressure in Nurses Working the Evening Shift (vs. Day Shift) on the Day the Monitor was Worn

Wave 3 (n=85)

	Work SBP N	Work SBP B	Work SBP p	Home SBP N	Home SBP B	Home SBP p	Sleep SBP N	Sleep SBP B	Sleep SBP p
Controlling for age only	85	4.042	0.199	83	6.978	0.030	84	9.307	0.005
Controlling for hours worked, age		2.633	0.458		8.053	0.027		9.055	0.017
Controlling for all variables		0.632	0.86		1.098	0.272		6.314	0.09

	Work DBP N	Work DBP B	Work DBP p	Home DBP N	Home DBP B	Home DBP p	Sleep DBP N	Sleep DBP B	Sleep DBP p
Controlling for age only	85	2.673	0.259	83	4.224	0.094	84	6.335	0.007
Controlling for hours worked, age		0.742	0.778		5.208	0.068		5.064	0.057
Controlling for all variables		-0.546	0.835		1.969	0.52		2.914	0.275

Wave 4 (n=73)

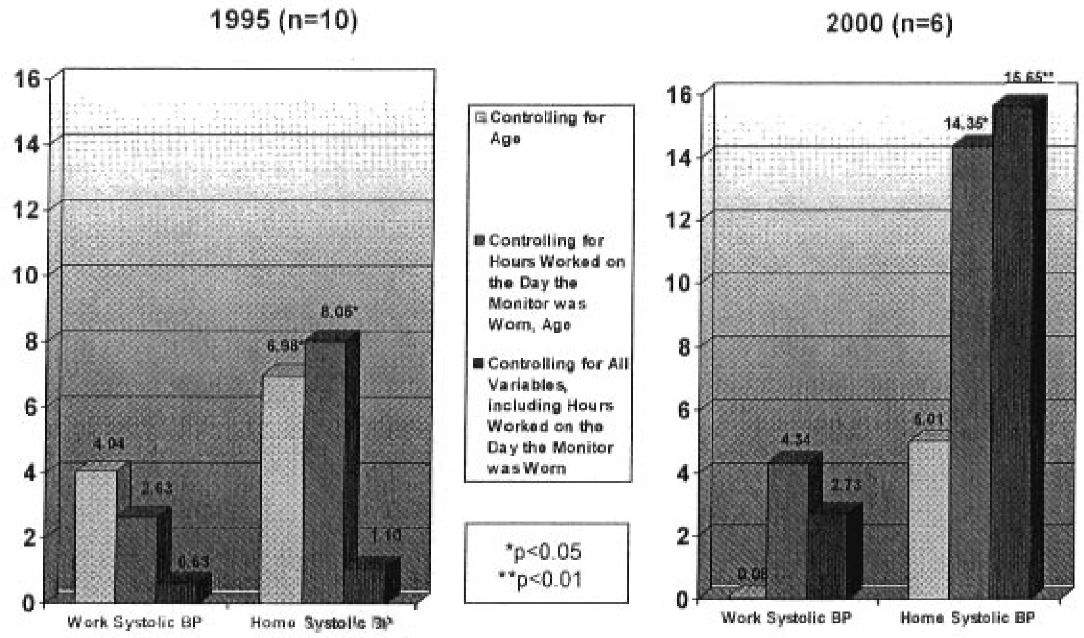
	Work SBP N	Work SBP B	Work SBP p	Home SBP N	Home SBP B	Home SBP p	Sleep SBP N	Sleep SBP B	Sleep SBP p
Controlling for age only	73	0.050	0.992	57	5.007	0.376	67	4.529	0.306
Controlling for hours worked, age		4.338	0.407		14.349	0.012		9.541	0.043
Controlling for all variables		2.733	0.624		15.647	0.005		4.144	0.423

	Work DBP N	Work DBP B	Work DBP p	Home DBP N	Home DBP B	Home DBP p	Sleep DBP N	Sleep DBP B	Sleep DBP p
Controlling for age only	73	-1.304	0.704	57	2.085	0.570	67	1.897	0.505
Controlling for hours worked, age		0.615	0.87		6.207	0.112		3.695	0.236
Controlling for all variables		-0.295	0.94		6.076	0.111		1.693	0.614

Note: Coefficient B represents the difference in ABP between evening shift workers (n=10 in 1995 and n=6 in 2000) and day shift workers (n=53 in 1995 and n=45 in 2000).

Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Figure 3. Blood Pressure on the Day the Monitor was Worn in Nurses who Worked the Evening Shift in 1995 and 2000



Exploratory Analyses: Interaction between Overtime Work Hours and Job Strain at Wave 4

At Wave 4, 47 nurses had valid home ABP averages and 14 did not have valid averages (a minimum of 5 ABP readings per location was required for averages to be considered valid). Therefore, in exploratory analyses, we examined differences between these two groups. The only substantial difference was the prevalence of job strain. We observed that nurses with valid Wave 4 home blood pressure readings (n=47) had a higher prevalence of job strain than the remaining nurses at Wave 4 (n=14) as well as the 36 other nurses who had participated at Wave 3 but not Wave 4. This suggested that the effect of overtime hours might be modified by job strain. Therefore, in additional exploratory analyses, we stratified our sample by job strain status and performed separate multiple regression analyses in each group (see **Table 9** and **Figures 4-7**).

Table 9. Estimated Difference in Ambulatory Blood Pressure Associated with each Additional Hour of Overtime, Stratified by Job Strain at Wave 4

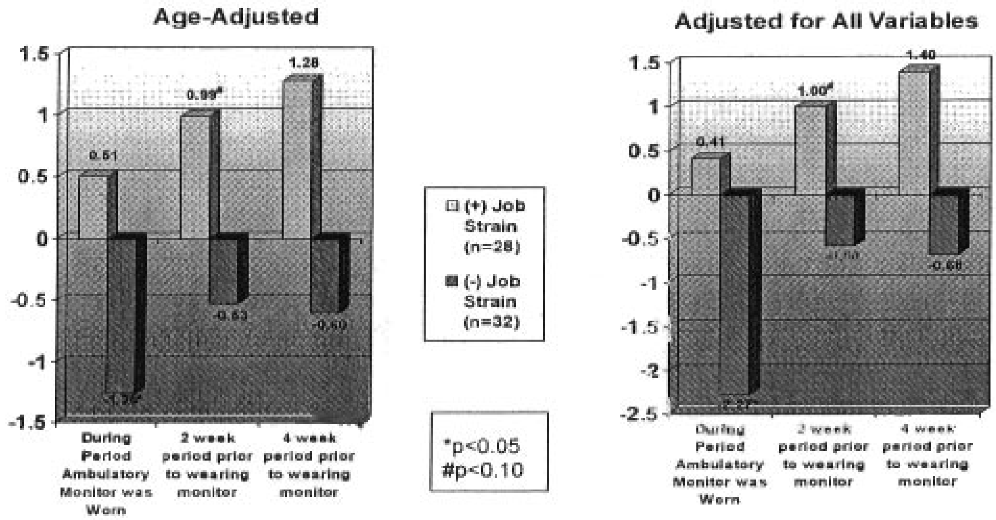
Variable		Job Strain (+)					Job Strain (-)			
		B*	p*	B#	p#		B*	p*	B#	p#
Work SBP	**(n=28)**					**(n=32)**				
During measurement period		0.513	0.241	0.408	0.370		-1.250	0.035	-2.267	0.003
2 weeks before		0.995	0.053	0.998	0.089		-0.528	0.288	-0.581	0.267
4 weeks before	(n=27)	1.279	0.112	1.398	0.152		-0.601	0.265	-0.682	0.192
Work DBP	**(n=28)**					**(n=32)**				
During measurement period		0.206	0.477	0.148	0.624		-0.832	0.081	-1.541	0.012
2 weeks before		0.383	0.268	0.205	0.595		-0.775	0.043	-0.875	0.027
4 weeks before	(n=27)	0.546	0.283	0.145	0.799		-0.803	0.055	-0.857	0.033
Home SBP	**(n=25)**					**(n=22)**				
During measurement period		1.260	0.038	0.668	0.230		-0.539	0.486	-0.306	0.707
2 weeks before		0.968	0.111	1.090	0.080		-0.121	0.956	-2.323	0.288
4 weeks before	(n=24)	1.367	0.137	0.788	0.406		-0.296	0.931	-1.361	0.592
Home DBP	**(n=25)**					**(n=22)**				
During measurement period		0.529	0.181	0.068	0.862		-0.239	0.690	-0.360	0.519
2 weeks before		0.198	0.615	-0.383	0.345		0.582	0.728	2.175	0.072
4 weeks before	(n=24)	0.652	0.238	-0.136	0.817		0.491	0.851	0.503	0.776
Sleep SBP	**(n=25)**					**(n=31)**				
During measurement period		0.021	0.960	-0.354	0.360		-0.403	0.545	-0.883	0.267
2 weeks before		0.900	0.052	-0.212	0.721		-0.145	0.766	0.186	0.737
4 weeks before	(n=24)	0.904	0.252	-1.175	0.180		0.032	0.952	0.227	0.687
Sleep DBP	**(n=25)**					**(n=31)**				
During measurement period		-0.120	0.557	-0.336	0.143		-0.361	0.460	-1.300	0.025
2 weeks before		0.101	0.671	-0.575	0.094		-0.062	0.862	0.377	0.351
4 weeks before	(n=24)	0.065	0.872	-0.766	0.150		0.007	0.985	0.371	0.354

*Controlling for Age, Shift worked, and Hours worked per shift

#Controlling for all variables, including shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

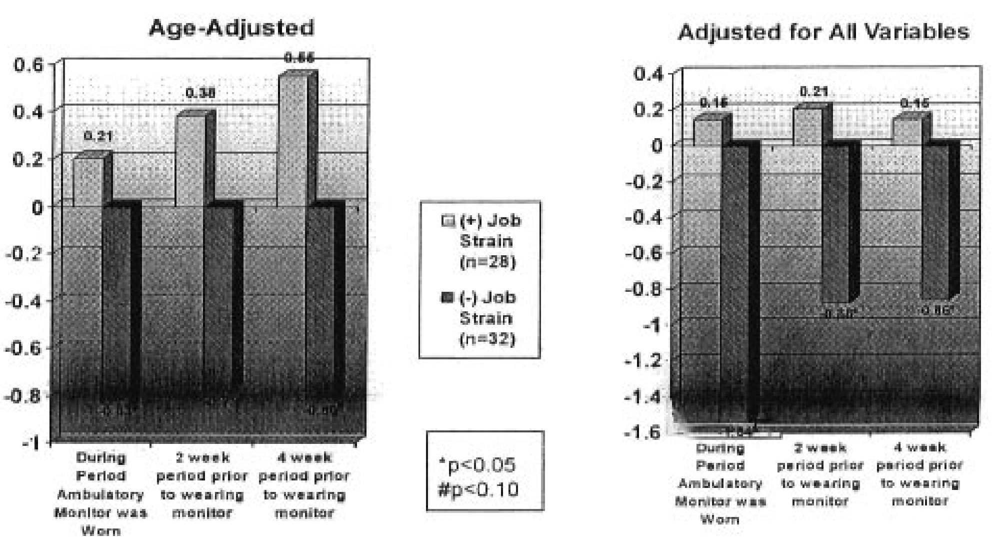
Figures 4-7. Estimated Difference in Ambulatory Blood Pressure Associated with each Additional Hour per Week of Overtime, Stratified by Job Strain at Wave 4

Figure 4. Estimated Difference in Ambulatory Work Systolic Blood Pressure Associated with each Additional Hour per Week of Overtime, Stratified by Job Strain, at Wave 4



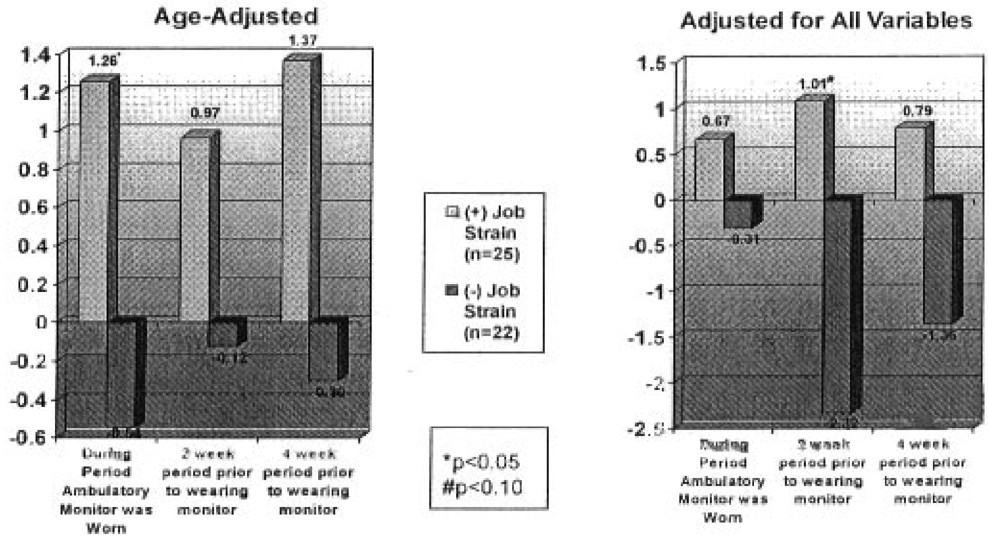
Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Figure 5. Estimated Difference in Ambulatory Work Diastolic Blood Pressure Associated with each Additional Hour per Week of Overtime, Stratified by Job Strain, at Wave 4



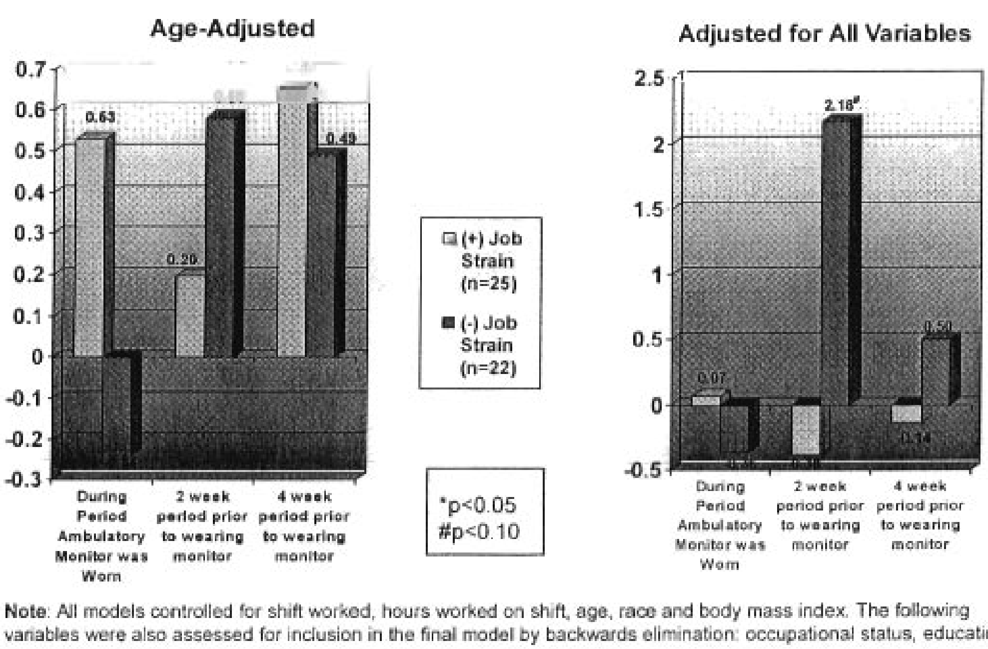
Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Figure 6. Estimated Difference in Ambulatory Home Systolic Blood Pressure Associated with each Additional Hour per Week of Overtime, Stratified by Job Strain, at Wave 4



Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Figure 7. Estimated Difference in Ambulatory Home Diastolic Blood Pressure Associated with each Additional Hour per Week of Overtime, Stratified by Job Strain, at Wave 4



Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

A significant interaction between overtime work during the month before the monitor was worn and job strain in predicting work ambulatory blood pressure was observed in 2000 (**Table 10**).

Table 10. Significance of Overtime x Job Strain Interaction Term at Wave 4 (adjusted for all variables)

	Work SBP	Work DBP	Home SBP	Home DBP	Sleep SBP	Sleep DBP
During measurement period	0.007	0.023	0.155	0.272	0.160	0.106
2 weeks before	0.018	0.032	0.943	0.194	0.467	0.870
4 weeks before	0.064	0.130	0.713	0.874	0.877	0.869

Note: All models controlled for shift worked, hours worked on shift, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

For nurses and aides reporting job strain (n=28), each overtime hour was associated with approximately 0.4 mm Hg greater work systolic blood pressure and 0.1 mm Hg greater work diastolic blood pressure. However, for those not reporting job strain (n=32), each overtime hour was associated with lower blood pressure: -2.3 mm Hg for work systolic blood pressure (**Figure 4**) and -1.5 mm Hg for work diastolic blood pressure (**Figure 5**). The p-values of the interaction terms were statistically significant for all three measurement periods for work systolic blood pressure and for the 2 weeks including ABP measurement and 2 weeks before ABP measurement for work diastolic blood pressure). The pattern of interaction between job strain and work hours, although not significant, was also observed for home systolic ABP for all three time periods and for home diastolic ABP, but only for the two weeks during which the ambulatory monitor was worn (see **Figures 6-7**), somewhat consistent with work ABP at Wave 4. However, such interactions were not found at Wave 3 (in 1995).

Exploratory Analyses: Interaction between Hours Worked on the Day the Monitor was Worn and Job Strain

As in the original analyses of hours worked on the day the monitor was worn (**Table 7**), analyses stratified by job strain showed strong and often significant associations between work hours and ABP at Wave 4 both for nurses reporting job strain and those not reporting job strain (**Table 11**).

Table 11. Associations between Hours Worked on the Day the Monitor was Worn and Ambulatory Blood Pressure, Stratified by Job Strain

Wave 3

Variable	Job Strain (+)					Job Strain (-)				
	n	B*	p*	B#	p#	n	B*	p*	B#	p#
Work SBP	35	-0.47	0.75	0.33	0.80	50	-0.37	0.64	-0.83	0.30
Home SBP	33	2.69	0.10	3.41	0.03	50	0.30	0.70	0.14	0.87
Sleep SBP	35	1.24	0.42	2.69	0.04	49	-0.14	0.87	-0.51	0.56
Work DBP	35	-2.22	0.05	-1.48	0.14	50	-0.28	0.66	-0.83	0.19
Home DBP	33	0.95	0.48	2.62	0.07	50	0.66	0.30	0.88	0.22
Sleep DBP	35	-0.50	0.65	1.05	0.32	49	-0.27	0.67	-0.67	0.31

Wave 4

Variable	Job Strain (+)					Job Strain (-)				
	n	B*	p*	B#	p#	n	B*	p*	B#	p#
Work SBP	35	2.47	0.08	1.90	0.24	38	1.36	0.27	0.43	0.73
Home SBP	30	3.46	0.02	1.90	0.18	27	4.35	0.01	6.56	0.00
Sleep SBP	30	2.06	0.11	1.80	0.16	37	2.02	0.08	1.35	0.28
Work DBP	34	1.01	0.26	0.36	0.72	38	0.36	0.71	-0.43	0.65
Home DBP	30	1.48	0.09	0.73	0.42	27	1.97	0.10	3.64	0.01
Sleep DBP	30	0.73	0.32	0.29	0.71	37	0.67	0.39	1.23	0.26

Note: Coefficient B represents the estimated increase in blood pressure (mm Hg) associated with each hour of overtime worked beyond 8 hours on the day of monitoring.

*Controlling for Age, Shift worked
#Controlling for all variables, including shift worked, age, race and body mass index. The following variables were also assessed for inclusion in the final model by backwards elimination: occupational status, education level, smoking, alcohol consumption, job physical exertion, and marital status.

Previously, at Wave 3, no significant positive associations had been observed (**Table 7**). However, in stratified analyses, associations between work hours and ABP among nurses reporting job strain were of greater magnitude than those not reporting job strain (**Table 11**). Three of the six adjusted associations among nurses reporting job strain at Wave 3 were statistically significant (home and sleep systolic BP and home diastolic BP). However, none of the interaction terms between work hours on the day the monitor was worn and job strain at Wave 3 or Wave 4 were statistically significant.

CONCLUSION

Study Findings

This study contributes to the body of research on the cardiovascular effects of long work hours and is one of the few studies in this area of research on women. We found evidence of associations between work, home and sleep ambulatory blood pressure (ABP) in female nurses and nurses' aides and work hours on the day the ABP monitor was worn. The magnitudes of associations at Wave 4 (1999-2000) were substantial. Twelve-hour shift workers' ABP was 4-19 mm Hg systolic and 3-8 mm Hg diastolic higher than 8-hour shift workers. However, such associations were not replicated at Wave 3 (1995).

In addition, nurses and aides who worked the evening shift had substantially higher work, home, and sleep ABP at both Wave 3 and Wave 4 compared to day shift nurses and aides. These associations reached statistical significance for home ABP for some models.

This study of female nurses and nurse aides did not provide evidence of an association between overtime work hours in the weeks preceding blood pressure measurement and ABP. While several significant associations were observed, given the number of tests conducted, these findings could be due solely to chance. However, associations between overtime hours in the weeks preceding blood pressure measurement and work systolic and diastolic ABP at Wave 4 (2000) were observed among employees reporting job strain. In the absence of job strain, overtime work hours were associated with lower work ABP. While these significant interactions are intriguing, they were not replicated at Wave 3, nor with sleep ambulatory blood pressure, nor with work hours on the day the monitor was worn.

These findings add to the evidence that work stressors can increase the blood pressure of women workers, and that various work stressors may interact with each other in increasing blood pressure. Prior studies which showed an association between long work hours and blood pressure were conducted only in men (109, 110).

Study Advantages and Limitations

This study had several methodological advantages. First, administrative data from the employer on past work hours was available for analyses. Thus, we did not have to rely on participants' memory of past work hours.

Second, blood pressure was measured by ambulatory monitoring, currently considered the "gold standard" of measuring blood pressure. The literature has demonstrated that ABP monitoring produces more reliable and valid measures of a person's blood pressure than single casual clinical measurements using a standard sphygmomanometer (53).

Third, data was available on shift worked (day versus evening/night) by study participants during the 24-hour period of ABP monitoring in 1995 and 2000. Since the health and cardiovascular effects of extended work hours and shift work are related, controlling for shift work in multivariate analyses allowed us to ascertain the independent effects of extended work hours and shift work on blood pressure.

There were also several limitations to this study. First, the sample size was relatively small, limiting statistical power, especially for interaction effects. For example, we did not test for interaction between overtime and age. In one prior study among men, with a larger sample size (n=264), effects of job strain were greater among older workers (102). Second, findings are specific to the health care sector. Further research is needed to determine to what extent the findings apply to women workers in other sectors.

Third, the definition of "overtime" as hours per week in excess of 37.5 hours per week is much lower than definitions used in other studies, which typically defined "overtime" as time worked greater than 50 or 60 hours per week (22, 23). In prior studies of long work hours and blood pressure, the exposed group was working >61 hours (41) or >55 hours per week (40).

In the current study, the average number of overtime hours worked during the 2-week pay periods during ABP monitoring, immediately before monitoring, and four weeks before monitoring ranged from 1.11 hours to 2.34 hours per week. Thus, the average number of hours worked per week remained under 40 hours, and more than half the study participants did not work any overtime hours during the 2-week period of ABP monitoring. A small percentage of nurses (12.1% in 1995 and 16.4% in 2000) worked more than 4 overtime hours per week during the 2-week pay period that the ambulatory monitor was worn, but the size of this subset of nurses was too small to have adequate power to test comparisons with the remainder of the nurses at Waves 3 or 4.

Most of the studies with statistically significant cardiovascular effects have defined overtime work hours as greater than 60 hours per week (22). Further research is needed with nurses and other primarily female populations that work a greater number of overtime hours than worked in this study to determine whether there is a threshold of effect of work hours on blood pressure.

Control for Confounders and/or Mediators

In cardiovascular disease research, some of the variables controlled for as potential confounders may, in fact, be mediators, that is, in the causal pathway between exposure and health outcome (74). Variables assessed in the current study which may be in the causal pathway between overtime and blood pressure include unhealthy behaviors which may increase as a result of long work hours (smoking, alcohol, and lack of leisure-time exercise) and body mass index (which may increase as a result of stress-induced overeating and lack of leisure-time exercise). If this is truly the case and these variables are actually mediators rather than confounders, then the results of this study based on age-adjustment alone would have been a more accurate representation of the association between overtime work hours and blood pressure, and the effect size reported in this paper would be a conservative estimate. However, smoking, alcohol and exercise are not at issue in this analysis. These variables were not retained in the final regression model since their p value was <0.20. In most models, there was very little reduction in effect estimates after controlling for BMI. Therefore, the data do not support the hypothesis of mediation of the effects of work hours and shifts on blood pressure by BMI, smoking, alcohol use, or exercise.

One recent study by Goldstein et al. (111) suggests that age-adjustment alone is preferable to adjustment for other potential confounders since age contributes greatly to blood pressure changes over time. Goldstein et al. (111) examined changes in ambulatory blood pressure over five years in healthy older adults and found that age contributed to the variance of blood pressure over five years, but none of the other standard cardiovascular risk factors that they examined – gender, education, body mass index, hours of exercise, alcohol intake, caffeine intake, lipid level, or glucose level – contributed to the variance in ambulatory blood pressure. In our study, there was a statistically significant increase in ambulatory blood pressure over the five year study period (1995-2000), but our study was not designed to address the factors associated with the large increase in blood pressure in our cohort of nurses, although Goldstein et al.'s study provides one direction for future research on this issue.

Interaction between Overtime Hours and Job Strain

Immediate overtime (work hours on the day the ABP monitor was worn) was substantially and consistently associated with blood pressure while past overtime was not, suggesting an acute effect of overtime work on blood pressure. The effect of past overtime hours appears only in interaction with job strain. Along with previous studies showing a main effect of job strain on blood pressure in men and women (112), this suggests that modest levels of overtime may increase duration of exposure to job strain, among workers already facing job strain. Among workers not facing job strain, modest levels of overtime do not have a pressor effect. The main effect of job strain remains to be tested in this sample.

Directions for Future Research

An important area for future research is the interplay of overtime hours with the hours spent fulfilling domestic responsibilities and resulting effects on cardiovascular health. Women spend more hours than men fulfilling domestic responsibilities; thus, the impact of this "double burden" faced by women on blood pressure and other cardiovascular risk factors needs to be examined (113).

In addition, work hours are not adequately integrated into current models of occupational stress. For example, Nishiyama (36) suggests that Karasek's job strain model does not adequately measure long work hours. Therefore, models of occupational stress should more adequately integrate extended work hours.

Implications for Prevention

The results of this study suggest that programs and policies to reduce work organization stressors, such as 12-hour shifts and job strain, particularly among nurses and nurse aides, should be implemented. Since the United States has now surpassed Japan as having the longest work hours of any developed country (114), this study also suggests the importance of determining the threshold number of hours above which work hours can have a detrimental effect on workers' blood pressure in particular and cardiovascular health in general. Several states have passed legislation to address these issues related to overtime work hours, at least for healthcare workers. For example, New Jersey passed a law in February 2004 prohibiting mandatory overtime, except in emergencies, for healthcare workers (115), making it the second state, after Washington state, to pass such legislation. Legislation prohibiting mandatory overtime for nurses is also pending in New York State (116). Work hours reform also went into effect July 1, 2003 for medical residents, limiting work hours to eighty hours per week, although this change was made within the medical profession through the Accreditation Council for Graduate Medical Education (ACGME) and not by government legislation (117). While these changes may help to address the negative impact of overtime hours on healthcare workers, further research with larger samples is needed to adequately understand thresholds of effect and possible interactions with other job stressors and demographic measures – in order to inform future prevention efforts.

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STUDY #4

LONG WORK HOURS, WORK STRESSORS, AMBULATORY BLOOD PRESSURE, AND PSYCHOLOGICAL/PSYCHOSOMATIC DISTRESS AMONG HOSPITAL WORKERS

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ABSTRACT

The effect of long work hours, shiftwork, and other work stressors were examined in relation to blood pressure (BP) and symptoms of depression, anxiety, fatigue and insomnia. The study sample included 239 hospital workers in lower status job titles and 27 home health aides in New York City who completed a psychosocial questionnaire. In addition, 175 of the participants volunteered to wear an ambulatory blood pressure (ABP) monitor for a complete work shift and had at least 5 valid BP readings. ABP monitoring is considered more reliable and valid and more highly correlated with target organ damage and cardiovascular disease than are casual (clinic) BP measurements.

No association was observed between long work hours and BP. However, ABP was elevated among employees working ≥41 (vs. <41) per week in the group with only a high school education (8.7 mm Hg systolic, 5.3 mm Hg diastolic), compared to no association or an inverse association among those with higher levels of education (interaction term, p>.10). Education was an independent predictor of BP. Participants with a high school education had ABP 18.4 mm Hg systolic and 12.1 mm Hg diastolic (p<.001) higher than those who had attended graduate school. Participants who had attended college but had not completed a four-year degree had ABP 10.4 mm Hg systolic (p=.02) and 5.9 mm Hg diastolic (p=.06) higher than those who had attended graduate school. Shiftworkers had significantly higher ABP only in models adjusted for age, race, and gender, 6.3 mm Hg systolic (p=.04) and 4.5 mm Hg diastolic (p=.03), but not in models adjusted for all demographic and biomedical risk factors. In analyses restricted to women (76% of participants), associations between job strain and effort-reward imbalance and ABP were statistically significant and in the range of 4.8-6.6 mm Hg systolic and 3.2-4.3 mm Hg diastolic.

Occult hypertension, that is, office BP <140/90, but elevated ABP, was observed in 16-

23% of men and 19-20% of women with office BP <140/90. Shiftwork was significantly associated with occult hypertension, however, long work hours were not. Modest elevations of risk of occult hypertension due to job strain or effort-reward imbalance in the range of 1.5-2.5 were observed, however, due to small sample size, most had a significance level of p>.10.

Work hours ≥41 per week were significantly associated with fatigue, but not with anxiety or insomnia. Work plus home hours ≥57.5 per week were associated with a substantially increased risk of depression (OR=4.34, 95% CI 1.80-10.47, p=.001). Job strain and effort-reward imbalance were associated with elevated risk of depression, anxiety, insomnia and fatigue.

This study adds to the literature on the effects of work stressors such as job strain, effort-reward imbalance and shiftwork on BP and on psychological/psychosomatic distress. It suggests that employees exposed to shiftwork, job strain, and effort-reward imbalance in particular need targeted ABP monitoring to determine whether they have occult hypertension. These findings need to replicated using larger samples, and with samples with a wider range of work hours and job titles.

This is the first study to test interactions between work hours (or effort-reward imbalance) and socioeconomic status on BP, and the first study to examine the association between long work hours and fatigue, as measured by Sluiter et al's "need for recovery" scale. This was only the second study to examine predictors of occult hypertension in the work environment. While rarely studied, occult hypertension is of major clinical significance. Because individuals with occult hypertension have a significantly increased risk of developing CVD compared to normotensives, they require counseling, possibly treatment, and workplace stressor assessment, but rarely receive these because their office BP appears normal. The current study helps to identify risk factors for the development of occult hypertension.

INTRODUCTION

This study was designed to examine the impact of long work hours and other sources of job stress on blood pressure, depression, anxiety, insomnia and fatigue among hospital and home health care workers. There is a growing body of research on long work hours and a wide variety of health effects, including work accidents and injuries, musculoskeletal disorders, fatigue, psychological symptoms, health behaviors, cardiovascular risk factors (such as high blood pressure (BP)) and cardiovascular disease (CVD) (1-4). However, many research questions remain on how overtime and extended work shifts influence worker health and safety (4).

Blood pressure elevation

Two Japanese studies found evidence linking overtime work and BP among men working greater than 55 hours per week. Iwasaki et al. found significantly elevated systolic BP among salesmen aged 50-60 years whose combined commute and work hours exceeded 61 hours per week as compared to those working 57 hours or less (5). However, no BP differences were reported in younger workers. Hayashi et al. observed higher BP in a group of white-collar employees working more than 60 hours of overtime per month as compared to those working less than 30 hours overtime per month (6). In addition, Hayashi et al. found that within another group of white-collar workers followed longitudinally, their BP was significantly higher and their sleep hours significantly lower when working more overtime (average 96 hours/month) as compared to a "control" period (average 43 hours/month of overtime). In contrast, Nakanishi et al. found that white-collar workers reporting 10 or more hours of work per day had a lower risk for developing hypertension when compared with workers reporting less than eight hours of work per day (7). In addition, Park et al. reported no correlation between BP and work hours in Korean engineers whose work hours during the previous month ranged from an average of 52 hours to 89 hours per week (8). A recent US study analyzed self-reported data from the California Health Information Survey and found that employees working more than 50 hours per week had a 29% increased risk of developing hypertension (OR=1.29, 95% CI: 1.10-1.52) compared to those working 11-39 hours per week (9). Only the study by Hayashi et al. (6) measured BP by averaging multiple readings at work using ambulatory monitoring methods.

Work-related psychosocial stressors have also been associated with BP. Employees reporting high effort combined with low reward at work have been found to have higher systolic ambulatory BP (10), increased risk of hypertension (11) and with a co-manifestation of hypertension and high LDL-cholesterol in men (12).

As of 2000, 10 cross-sectional studies of job strain (or its components) and ambulatory blood pressure (ABP) among men have been published. Many reveal significant positive associations with work BP (13). In the five studies where measurements were also made outside of work, job strain was associated with leisure time systolic ABP. Of the six cross-sectional studies of job strain and ABP among women, four indicate a significant positive association with work systolic ABP (14). Work systolic ABP among employees facing job strain is typically 4-8 mm Hg higher than those without job strain.

In the New York City Work Site Blood Pressure Study (WSBPS), the only long-term prospective study of psychosocial factors and ABP, at the first round of data collection (Time 1), men employed in "high strain" jobs had higher levels of work (6.7 mm Hg systolic, 2.7 mm Hg diastolic), home and sleep ABP, controlling for potential risk factors (15, 16). The group exposed to job strain both at Time 1 and three years later (chronically exposure) exhibited an 11-12 mm Hg higher systolic and 6-9 mm Hg higher diastolic work ABP than the group unexposed at both times.

Effect modification

Several studies have suggested that work stressors may interact with each other in producing ill health. For example, the cross-sectional association between job strain and BP was substantially greater for men with lower socioeconomic status (SES) in New York City (17), as well as men and women in Framingham (18). The impact of long work hours on health may be greater for older workers (2, 5), shift workers (4) and workers in stressful jobs, such as professional drivers (19). Therefore, the proposed study will examine the interaction between long work hours, job strain and effort-reward imbalance and between SES and both long work hours and other job stressors.

Ambulatory blood pressure monitoring

While few studies of job strain and casual clinic BP have shown significant associations (13, 20), with the exception of a very large study (n=8395) (21), strong evidence of an association is found in studies where BP is measured by an ambulatory (portable) monitor (13). This difference in findings may be explained, in part, by the imprecision and possible biases of taking "casual" BP measurements. For example, relaxation can occur when people are away from work resulting in lower BP. There are also various atypical psychosocial stimuli present in a clinic that can affect BP, such as anxiety due to seeing a doctor. An alternative method of measuring BP is ambulatory monitoring, in which a person wears an automatic monitor on his or her arm throughout the workday (22). Compared to casual BP measurements, ambulatory monitoring provides a more reliable measure of BP, since there is no observer bias and the number of readings is increased. It is also a more valid measure of average BP, since BP is measured during a person's normal daily activities and exposure to the daily stressors that influence persistent increases in BP. Ambulatory BP is also a better predictor than casual clinic

BP of target organ damage (23), and CVD (24). Therefore, ABP monitoring was used in the current study.

Occult hypertension

ABP monitoring allows for the identification of occult (also known as hidden or masked) hypertension, i.e., elevated BP while working or over 24 hours, but normal in an office setting. Occult hypertension is a rarely studied entity, but of major clinical significance. People with occult hypertension have levels of target organ damage, such as left ventricular mass index (25, 26) or carotid plaque (25), similar to diagnosed hypertensives and significantly higher than normotensives. Patients with occult hypertension have a significantly increased risk of developing CVD (24, 27).

People with occult hypertension, and no previous diagnosis of hypertension, require counseling, possibly treatment, and workplace stressor assessment, but rarely receive these because their office BP appears normal. Little evidence exists on the prevalence and predictors of hidden hypertension, however its prevalence in the general population could be as high as 10% (28). Among Kent, Ohio women, 28/103 (27%) had ambulatory systolic BP >= 140 mm Hg, but clinic systolic BP <140 (29), and hidden hypertension was more prevalent in blue-collar women (39%) than in clerical (28%) or white-collar (21%) women. Other studies, with a variety of criteria for determining occult hypertension and a variety of study populations found the following prevalences: 17% among Italian hypertensive patients (24); 11% among normotensive Italians in a population-based study (26); 23% among Canadian normotensive volunteers; and 10.2% borderline plus 3.2% definite hypertension in Japanese community-based volunteers (30). Several studies have identified predictors of occult hypertension, including male gender (24, 31, 32), cigarette smoking (24, 31, 32), coffee (24), alcohol (32), and older age (32). However, no published studies have examined work organization predictors of occult hypertension. Therefore, associations of occult hypertension with long work hours, job strain and other job stressors are examined in the current study.

Psychological/psychosomatic health impacts

In several studies, associations have been found between job stressors and anxiety (33-35) and depression (33, 36-38). Therefore, associations between these health outcomes, along with fatigue and insomnia, with long work hours and other job stressors, are examined in the current study.

METHODS

Assembly of study sample

Study volunteers were recruited from employees at one hospital and from home health care workers in New York City between September 2004 and September 2005. Volunteers were recruited through announcements at meetings of the 1199SEIU United Healthcare Workers East union, personal contacts/word of mouth, fliers distributed throughout the hospital, hospital newsletter articles, and fliers mailed to home health care workers. Volunteers were eligible for the study if they had worked at the hospital or as a home health aide for at least one year and were at least 18 years of age. Study staff organized two focus groups of home health aides in February and March 2004, and a focus group of hospital workers in September 2004, to discuss issues of concern to them regarding working conditions and workplace health and safety. Questions were added to the study questionnaire based on issues raised by members of the focus groups. Participants completed a questionnaire, then had their BP monitored throughout a work-shift, and were compensated $25 for their time and effort.

Of 82 home health care volunteers, two did not meet eligibility criteria, two later decided not to participate, and 51 never completed the questionnaire, leaving 27 eligible employees with complete survey information (a response rate of 35% (27/78) of eligible volunteers). All 27 home health care workers with complete survey data were members of 1199SEIU. Of the 27, 10 wore an ambulatory BP monitor, 10 wore a wrist BP monitor, and 7 wore both monitors on a work shift. Two workers who attempted to wear the ambulatory monitor decided not to continue the monitoring, one who did not feel well due to pregnancy, and the other "could not tolerate" the ambulatory BP monitor.

Of 314 hospital volunteers, four did not meet eligibility criteria, 14 later decided not to participate, 4 could be contacted, and 53 never completed the questionnaire, leaving 239 eligible employees with complete survey information (a response rate of 77% (239/310) of eligible volunteers). 191 (80%) of the 239 participants with complete survey data were members of 1199SEIU. Of the 239 employees with complete survey data, 175 wore the ambulatory BP monitor and 161 wore the wrist BP monitor, 138 wore both monitors and 186 wore one of the two monitors. Fifty-three employees who were scheduled to wear the monitors could not because funding for the study terminated. None of the 239 participants with complete survey data refused to wear a BP monitor.

The median time between return of the completed survey and BP monitoring was 28 days (range 0-147, n=187). Study participant recruitment procedures were approved by the Mount Sinai Institutional Review Board.

Blood pressure monitoring

On the day that their BP was to be monitored, hospital participants met with a trained technician either at the study office (in the hospital) or at their work location. Home care participants met the technician either at their agency or at their own home.

Participants had their BP taken three times, in a seated position, simultaneously using an upper arm aneroid sphygmomanometer and a Spacelabs 90207 or 90217 portable ambulatory (ABP) monitor connected to the same upper arm cuff. After each upper arm reading, after a delay of one minute, a wrist measurement was obtained using the OMRON HEM-637 wrist monitor. To be acceptable for the study (to be considered valid), readings from the upper arm Spacelabs ABP monitor and the Omron HEM-637 wrist monitor each had to be within ±10 mm Hg of the aneroid sphygmomanometer (22). In total, each participant had his or her BP taken 6 times (3 aneroid sphygmomanometer and ABP readings simultaneously and then 3 wrist monitor readings) before the start of a work shift. The aneroid sphygmomanometer readings served as the "casual office" BP readings for the study.

The ABP monitor is worn under the clothes and attached to a participant's upper arm through a cuff that inflates automatically at pre-determined intervals. During a participant's work shift, the ABP monitor was programmed to take a reading automatically every 30 minutes. Unlike wrist monitors, ABP monitors are not removed between readings, and do not have to be activated by the participant. As participants felt the upper arm cuff inflate, they were told to keep their arm as still as possible. (However, some arm movement will usually not interfere with the monitor's ability to take a valid reading.) Once the cuff had deflated, participants were asked to wait one minute and then put on and trigger the wrist monitor by pressing the "on" button and holding it at heart level. They were also asked to complete a short written diary in which they wrote down the time of the reading, their location (work or home), and their position (standing, sitting, or lying down). This information was used to compute work averages of both systolic and diastolic BP. Both the ABP monitor and the wrist cuff digitally store BP measurements.

Participants were asked to return the ABP and wrist cuffs and the diary to the study office after their shift or the next day. For home care workers not in the immediate vicinity of the hospital, study staff traveled to their location the following day to retrieve the equipment and diary.

Following these measurements, participants were mailed a sealed envelope containing the average of their ABP readings. The letter stated that the study results were not a medical diagnosis, but that "If your readings are above normal, you should have your pressure checked again, and see your primary care provider. Please note that as an 1199 member, you can receive a free and confidential follow-up at the1199 Worksite Wellness Program at xxx Hospital." Participants were warned that if their readings were over160/100 mm Hg, they should seek immediate medical attention.

Psychosocial questionnaire

Before blood pressure measurements, participants completed a questionnaire packet, which included the Job Content Questionnaire (JCQ), a widely used, well-validated instrument, based, in part, on questions drawn from the 1969-77 national U.S. Quality of Employment Surveys (39-41). The following three JCQ scales/items were used:

Job decision latitude was considered the sum of two equally weighted subscales: 1) skill utilization (keep learning new things, can develop skills, job requires skill, job involves task variety, job is repetitious (reverse scored), job requires creativity) and 2) decision authority (have freedom to make decisions, can choose how to perform the work, have a lot of say on the job).

Psychological job demands were defined by five items (excessive work, conflicting demands, insufficient time to do the work, work fast, work hard). Internal consistency reliability (Cronbach's alpha) was 0.58 for job demands and 0.71 for job-decision latitude. In the New York City WSBPS, the three-year test-retest reliability was r=0.64 for both of these scales (42).

Physical job demands was measured by a single item (job requires lots of physical effort). In the New York City WSBPS, this item had a three-year test-retest reliability of r=0.67 (43).

Participants also completed another widely used but more recent instrument, Siegrist's effort-reward imbalance (ERI) questionnaire (44, 45). The following two equally weighted ERI scales were used:

Effort at work was defined by six items: time pressure due to work load; interruptions and disturbances; responsibility; pressure to work overtime; physically demanding; and increasing job demands (Cronbach's alpha=0.69).

Rewards from work is defined by 11 items, including adequate income, "esteem reward" (respect from superiors and coworkers, adequate support, unfair treatment (-), deserved prestige) and "status control" (poor promotion prospects (-), poor job security (-), undesirable change in work situation (-), current occupational position adequately reflects education) (Cronbach's alpha=0.74).

Questions on work schedules included hours worked per week on main health care job and on second job (if any), shift schedule, and hours worked per week on tasks at home. Demographic questions included gender, race/ethnicity, age, education, income, marital status, and job category. The hospital workers union, 1199SEIU, had created six job categories for hospital work for administrative purposes. These categories, in order of increasing status, were: service/maintenance, clerical, licensed practical nurse (LPN), technical, registered nurse (RN) and paraprofessional.

Biomedical and behavioral questions were derived from the New York City WSBPS questionnaire (42, 46) and included hours per week of leisure time physical exertion, height, weight, current pregnancy (yes/no), current or past diabetes (yes/no), current medication for high blood pressure (yes/no), ever diagnosed with hypertension (yes/no), and family history of hypertension (either mother or father died before age 60 from or was diagnosed with high blood pressure). Body mass index (BMI) was computed as weight (kg)/height $(m)^2$. Quantity of alcohol consumption was the sum of the number of glasses of wine, bottles or cans of beer (12 oz.), and mixed drinks (1 shot of liquor) usually consumed per week (47). Current smoking was based on one question ("do you smoke cigarettes?" (yes/no)), which had a three-year test-retest reliability of 0.69 (kappa) in the New York City WSBPS.

The following measures of psychological and psychosomatic strain were also obtained by questionnaire and analyzed as health outcome variables:

Depression was measured by a version of the 20-item Center for Epidemiologic Studies Depression Scale revised by Eaton et al. (CESDR) (48). The CESDR also had very good internal consistency reliability (Cronbach's alpha=.91). Items asked about symptoms of depression during the past week. Response options were: "Not at all or less than once/day" (0), "1-2 days" (1), "3-4 days" (2), "5-7 days" (3), "nearly everyday for 2 weeks" (4). Caseness of depression was defined as the sum of the 20 items ≥16 (48).

Anxiety. The 4-item Anxiety subscale of the General Well-Being Schedule had very good internal consistency reliability (Cronbach's alpha=.87) (49). Items were: "during the past month, bothered by nervousness or "nerves"; felt under strain, stress, or pressure; anxious, worried, or upset; how relaxed or tense have you been (on a scale from 1-10). Anxiety scores were categorized into low (0-6), moderate (7-12) and high (13-25) based on the method of Jonas and Lando (50).

Sleeping problems were measured by seven questions from the Sleep Heart Health Study: a. Have trouble falling asleep; b. Wake up during the night and have difficulty getting back to sleep; c. Wake up early in the morning and be unable to get back to sleep; d. Feel unrested during the day, no matter how many hours of sleep you had; e. Feel excessively (overly) sleepy during the day; f. Do not get enough sleep; g. Take sleeping pills or other medication to help you sleep (51). Response options were: "never", "rarely" (1/month or less), "sometimes" (2-4 times/month), "often" (5-15 times/month), or "almost always" (16-30 times/ month). "Insomnia" was defined as a response of "often" or "almost always" to any one of questions a, b, c, or g (51).

Fatigue was measured by the sum of 11 dichotomous items from the "need for recovery" scale originally developed by Van Veldhoven and Meijman and translated by Sluiter et al. (52). Items refer to the time period of the end of a work day and include: "hard to relax", "really feeling worn-out", "exhausted", "still feeling fresh" (-), "able to relax only on a second day off", "trouble concentrating", "hard to show interest in other people", "takes me over an hour to feel fully recovered", "people should leave me alone for some time", "too tired to start other activities", "cannot optimally perform my job because of fatigue sometimes". Each question is scored "1" (yes) or "0" (no). Internal consistency reliability was good (Cronbach's alpha=.87).

Psychological/psychosomatic distress. For the current study, a dichotomous summary measure of "psychological/psychosomatic distress" was created. Study participants were coded as "1" (yes) if they scored above the threshold for depression (48), high anxiety (50) or insomnia (51). Otherwise they were coded "0" (no).

Computation of work exposures

Job strain. The combination of high psychological job demands and low job decision latitude, which defines "job strain", was modeled using the previously reported job strain "quadrant" term (16, 46, 53). National averages for all employees from the 1969-1977 U.S. QES were used as reference points (41). Job strain based on these cutpoints was defined as job demands >30.9 and decision latitude <70.34.

Effort-reward imbalance. The interaction between job efforts and rewards was computed using the formulas of Siegrist and Peter (44, 54). The sum of the six effort items equaled E and the sum of the 11 reward items equaled R. The formula E/(R*6/11) produces a ratio score, which equally weights efforts and rewards. Higher values represent more job stress, that is, greater effort combined with lower reward. This ratio was dichotomized so that "effort-reward imbalance" is defined as E/(R*6/11) > 1.

Job strain plus effort-reward imbalance. For the current study, a dichotomous summary measure of "job strain plus effort-reward imbalance" was created to determine the health effects of combined exposure to two well studied job stress constructs. Study participants were coded as "1" (yes) if they met the definition for both job strain and effort-reward imbalance.

Work hours. Hours usually worked per week on the participant's health care job and on a second paid job (if any) were summed into a measure of "total paid hours/week". This work hour measure was then summed with hours worked per week on tasks at home to create a measure of "total paid + home hours/week".

Shiftwork. Since about 75% about the sample worked regular day shifts, for the purposes of data analysis, participants reporting work on evening or night shifts, or rotating shifts, were classified as having 'shiftwork".

Computation of measures of blood pressure

Systolic and diastolic ABP and wrist readings obtained during work hours for each participant (as defined by diary records) were averaged. When fewer than five readings were obtained at work, the corresponding average was treated as missing data. Five readings are considered minimally sufficient to produce reliable estimates of mean work BP (55). Five or more work readings were obtained from 175 ABP participants, 134 wrist BP participants and 118 participants who wore both monitors. On average, the number of valid work readings was 15.8 ±6.5 ABP and 12.7 ±8.7 wrist. Calibration (office) BP readings were available for 174 participants.

High blood pressure. The National Heart, Lung and Blood Institute currently defines a "normal" blood pressure for an adult at rest as 120/80 mmHg or less. "Pre-hypertension" is the name given to BP between 121/81 and 139/89, and "hypertension" is defined as BP equal to 140/90 or higher (56). Therefore, the proportion of participants in each of these categories (as well as mean BP) was computed for ABP, wrist and calibration BP readings.

Comparisons between ABP and wrist readings. To help determine the validity of the newer wrist BP monitor, the difference between ABP and wrist work BP averages for each participant was computed. In addition, mean differences between ABP and wrist work BP were categorized as either within ±5 mm Hg or not, and within ±10mmHg

Occult hypertension has been defined in different ways in the literature. Therefore, three varied definitions of occult hypertension were utilized in the current study: SBP ≥136 or DBP ≥87 (for men) or SBP ≥131 or DBP ≥86 (for women) (57); SBP ≥135 or DBP ≥85 (24, 32); and SBP ≥140 or DBP ≥90 (58). When assessing work, demographic, or biomedical variables that might be considered predictors of occult hypertension, we would expect that associations with the predictor would be observed across definitions.

Data Analysis

Data entry and correction. All questionnaire data was double entered. Missing or ambiguous electronic data on gender, work hours, and job category was compared to written questionnaire data by study staff and corrections made to the electronic data set. Thus, there was no missing data on gender, work hours or job category for purposes of data analyses. The number of participants with missing data on other variables is presented in Tables 1-4.

Missing data. For the purpose of multivariate data analyses, participants with missing values on age, BMI, physical job demands and for questions used to define the components of job strain (job demands and job decision latitude) and the components of ERI (efforts and rewards) were assigned the mean value. For the same purpose, participants with missing values on potential confounders, diabetes, pregnancy, hypertension diagnosis, hypertension medication, family history of hypertension, hours of leisure time exercise per week, smoking, or alcoholic drinks per week were assumed to have a value of "0". For categorical variables where this assumption could not reasonably or logically be made, participants with missing values were assigned the modal value ("African American" for race/ethnicity, "some college" for education, "married" for marital status, and "day" for shift worked).

Multiple linear regression. Associations between work stressors (long work hours, shift work, job strain and effort-reward imbalance), job category, education and work systolic and diastolic blood pressure were examined by multiple linear regression. The first step of regression analyses for blood pressure included the stressor and potential confounders, age (years), gender and race/ ethnicity (Caucasian, Black, and Hispanic and other). The second step included additional confounders, education (5 categories), job physical demands, marital status (married vs. not married), family history of hypertension (yes/no), pregnancy (yes/no), and current use of hypertension medication (yes/no). The third step included potential mediators of the associations, BMI, current smoker (yes/no), number of alcoholic drinks per week, hours per week of leisure time exercise (4 categories), and diabetes (yes/no). An additional step included the stressors (job strain, ERI, shiftwork) and socioeconomic status (job category, education) in the same model.

One psychological/psychosomatic health outcome measure (fatigue) was continuous and thus a similar regression model was used for analysis, but with a shorter list of control variables. The first step of regression analyses included the stressor and potential confounders, age, gender and race/ethnicity. The second step included education, marital status, pregnancy, BMI, current smoker, alcoholic drinks/week, and leisure time exercise.

To assess potential interactions between exposure measures, six interaction terms were created between stressors (job strain, effort-reward imbalance, job strain plus effort-reward imbalance, shiftwork, paid work hours ≥41/week, and paid plus home hours ≥57.5/week) and natural categories of education (high school, some college and college graduate). Similarly, four interaction terms were created between stressors (job strain, effort-reward imbalance) and dichotomized work hours (paid work hours ≥41/week, and paid plus home hours ≥57.5/week). Six dummy variables were created for interaction with education, and four dummy variables were created for interactions with work hours, to assess the pattern of interaction. The reference group was the one with the least hypothesized health effect, i.e., low levels of a job stressor and higher SES. The statistical significance of the hypothesized interaction was assessed by multiplying stressor variables with education or with work hours, adding the product terms to the model that already includes main effects and examining the F-statistic for the change in R^2.

Multiple logistic regression. Associations between work stressors, education and the three definitions of occult hypertension were examined by multiple logistic regression. The first step of regression analyses included the exposure variable and potential confounders, age, gender and race/ethnicity. The second step included education, physical job demands, marital status, family history of hypertension, current use of hypertension medication, pregnancy, BMI, current smoker, alcoholic drinks/week, leisure time exercise, and diabetes

Associations with dichotomous psychological/psychosomatic health outcome measures (depression, anxiety, insomnia, and distress) were also assessed by multiple logistic regression, but with a shorter list of control variables. The first step of regression analyses included the stressor and potential confounders, age, gender and race/ethnicity. The second step included education, marital status, pregnancy, BMI, current smoker, alcoholic drinks/week, and leisure time exercise. Analyses were conducted using SPSS v. 13.

RESULTS

Demographics of study sample

The study sample consisted of 266 health care workers, and 75.6% of whom were female (Table 1). The average age of study participants was 44.5 years (range 21-76). Nearly half were African-American and about one-quarter had only a high education. The most frequent job category was clerical (38.7%), which consisted of jobtitles such as clerk, secretary, intake and discharge representative, accounts payable and receivable representative, administrative assistant, unit head, receptionist, and telephone operator. Only about one-third of the study sample was involved in direct patient care, in jobtitles such as registered nurse (6.0%), licensed practical nurse and certified nurse assistant (17.3%) and home health care worker (10.2%).

Work hours and other work stressors

Evening, night or rotating shifts were worked by 24.8% of the sample (Table 3), and shiftwork was more common among men (χ^2=5.76, df=1, p=.02) and among workers with lower levels of education (χ^2=14.86, df=4, p=.005). Job strain and effort-reward imbalance were highly prevalent, being reported by more than half of the participants with non-missing data. The combination of job strain and effort-reward imbalance was reported by about one-third of the

Table 1. Demographics of study sample (n=266)

	Hospital workers		Home care workers		Total	
	N	%	N	%	N	%
Total	**239**	**100%**	**27**	**100%**	**266**	**100%**
Gender: Female	178	74.5%	23	85.2%	201	75.6%
Male	61	25.5%	4	14.8%	65	24.4%
Race/Ethnicity:						
Black	111	46.4%	17	63.0%	128	48.1%
White	29	12.1%	4	14.8%	33	24.8%
Hispanic	65	27.2%	1	3.7%	66	12.4%
Asian	12	5.0%	0	0.0%	12	4.5%
Other	20	8.4%	4	14.8%	24	9.0%
Missing	2	0.8%	1	3.7%	3	1.1%
Education:						
Some high school	10	4.2%	2	7.4%	12	4.5%
High school diploma	54	22.6%	7	25.9%	61	22.9%
Some College	114	47.7%	13	48.1%	127	47.7%
BA	35	14.6%	2	7.4%	37	13.9%
Graduate School	22	9.2%	1	3.7%	23	8.6%
Missing	4	1.7%	2	7.4%	6	2.3%
Household income last yr:						
< $25,000	11	4.6%	10	37.0%	21	7.9%
25,000-$40,000	94	39.3%	11	40.7%	105	39.5%
$40,000-$55,000	40	16.7%	4	14.8%	44	16.5%
$55,000-$70,000	38	15.9%	0	0.0%	38	14.3%
$70,000-$85,000	18	7.5%	0	0.0%	18	6.8%
>$85,000	23	9.6%	0	0.0%	23	8.6%
Missing	15	6.3%	2	7.4%	17	6.4%
Hospital jobtitle:						
Service/Maintenance	31	13.0%	--	--	31	13.0%
Clerical	103	43.1%	--	--	103	43.1%
LPN	46	19.2%	--	--	46	19.2%
Technical	31	13.0%	--	--	31	13.0%
RN	16	6.7%	--	--	16	6.7%
Paraprofessional	12	5.0%	--	--	12	5.0%
Marital status:						
Married	103	43.1%	11	40.7%	114	42.9%
Divorced/separated	42	17.6%	7	25.9%	49	18.4%
Widowed	7	2.9%	1	3.7%	8	3.0%
Living as married	21	8.8%	1	3.7%	22	8.3%
Never married	61	25.5%	6	22.2%	67	25.2%
Missing	5	2.1%	1	3.7%	6	2.3%

	N	mean	s.d	N	mean	s.d.	N	mean	s.d.
Age	222	44.4	11.83	26	45.4	9.48	248	44.5	11.60

Table 2. Potential confounders (risk factors for blood pressure elevation) (n=266)

	Hospital workers		Home care workers		Total	
	N	**%**	**N**	**%**	**N**	**%**
Total	**239**	**100%**	**27**	**100%**	**266**	**100%**
Current smoker	36	15.1%	6	22.2%	42	15.8%
Alcohol use:						
non-drinker	139	58.2%	17	63.0%	156	58.6%
Light drinker	77	32.2%	5	18.5%	82	30.8%
Light to moderate drinker	12	5.0%	3	11.1%	15	5.6%
Moderate+ drinker	9	3.7%	2	7.4%	11	4.2%
Missing	2	0.8%	0	0.0%	2	0.8%
Alcoholic drinks/week:						
0	160	66.9%	20	74.1%	180	67.7%
1-2	38	15.8%	1	3.7%	39	14.6%
3-4	27	11.3%	4	14.8%	31	11.6%
5-9	12	4.9%	0	0.0%	12	4.6%
10+	2	0.8%	2	7.4%	4	1.6%
Diabetes	10	4.2%	3	11.1%	13	3.9%
Pregnancy	22	9.2%	1	3.7%	23	8.6%
Hypertension:						
family hx	142	59.4%	17	63.0%	159	59.8%
medication	58	24.3%	6	22.2%	64	24.1%
diagnosis	59	24.7%	8	29.6%	67	25.2
Leisure-time exercise/week:						
<1 hr	120	50.2%	15	55.5%	135	50.8%
1-3 hrs	73	30.5%	5	18.5%	78	29.3
4-6 hrs	29	12.1%	5	18.5%	34	12.8
>6 hrs	17	7.1%	2	7.4%	19	7.1%

	N	**mean**	**s.d.**	**N**	**mean**	**s.d.**	**N**	**mean**	**s.d.**
Body mass index	228	28.5	5.84	24	32.5	8.61	252	28.9	6.25
Job physical demands (1-4)	239	2.7	0.88	27	3.2	0.72	266	2.7	0.87

Table 3. Work hours and work organization exposures (n=266)

	Hospital workers		Home care workers		Total	
	N	%	N	%	N	%
Total	**239**	**100%**	**27**	**100%**	**266**	**100%**
Shift:						
day	179	74.9%	15	55.6%	194	72.9%
evening	34	14.2%	5	18.5%	39	14.7%
night	2	0.8%	6	22.2%	8	3.0%
rotating	18	7.5%	1	3.7%	19	7.1%
missing	6	2.5%	0	0.0%	6	2.3%
Job strain	111	46.4%	9	33.3%	120	45.1%
missing	32	13.4%	5	18.5%	37	13.9%
Effort/Reward >1	102	42.7%	12	44.4%	114	42.9%
missing	55	23.0%	11	40.7%	66	24.8%
Job strain and E/R>1	64	26.8%	3	11.1%	67	25.2%
missing	55	23.0%	10	37.0%	65	24.4%
Total paid hrs/wk						
32 or fewer	11	4.6%	2	7.4%	13	4.9%
35 to 40	178	74.5	17	63.0%	195	73.3%
40.5 to 48	31	13.0	4	14.8%	35	13.2%
50+	19	7.9	4	14.8%	23	8.6%
Total paid+home hrs/wk:						
<41.5	57	23.8%	7	25.9%	64	24.1%
41.5 to 47.9	71	29.7%	6	22.2%	77	28.9%
48 to 60	68	28.5%	7	25.9%	75	28.2%
>60	43	18.0%	7	25.9%	50	18.8%

	N	**mean**	**s.d.**	**N**	**mean**	**s.d.**	**N**	**mn**	**s.d.**
Job demands	216	33.8	5.76	26	30.3	4.52	242	33.4	5.73
Job decision latitude	213	63.1	11.15	23	58.2	12.08	236	62.6	11.30
Effort	211	16.4	2.93	20	17.3	2.51	231	16.5	2.90
Reward	201	28.7	4.61	20	26.5	3.62	221	28.5	4.57
ERI	184	1.1	0.35	16	1.2	0.26	200	1.1	0.35
Total paid hours per week	239	39.7	6.93	27	41.0	7.94	266	39.8	7.03
Health care	239	38.6	4.80	27	38.2	7.43	266	38.5	5.11
Second job	239	1.1	4.41	27	2.9	5.13	266	1.3	4.51
Home hours per week	239	11.4	12.36	27	11.2	14.08	266	11.3	12.52
Total paid plus home hours	239	51.1	14.08	27	52.2	16.28	266	51.2	14.29

participants with non-missing data. Long work hours, on the other hand, were not common in the study sample. Only 8.6% typically worked 50 or more hours per week. When work hours were combined with hours performing tasks at home, 18.8% of the sample reported working at least 60 hours per week in paid work and home activities. Gender was not significantly associated with work hours, home hours, education, job strain, or effort-reward imbalance.

Psychological/psychosomatic distress

Depressive symptoms greater than the CESDR threshold were reported by 11.3% of participants, high levels of anxiety by 28.6%, insomnia by 31.6%, and the measure of depression or high anxiety or insomnia by nearly half of the sample (47.0%) (Table 4).

Blood pressure

Hypertension (BP >140/90) was evident in 20.6% of the sample using work ABP readings, but only in 13.2% using calibration (office) BP readings (Table 5). Current use of hypertension medication was reported by 24.1% of the sample (Table 2). Mean work systolic BP readings using the ABP monitor and the wrist monitor were within ±5 mm Hg of each for 42.4% of the sample, and within ±10 mm Hg for 71.2% of the sample.

Occult hypertension

ABP (minimum of 5 work readings) and calibration data was available for 164 participants, and 134 had calibration BP <140 systolic and <90 diastolic. The prevalence of occult hypertension varied depending upon the definition used. The prevalence using ABP readings varied from 4.5% using the most restrictive definition (SBP ≥140 or DBP ≥90 (58)) to 20.1% using the definition of Pierdomenico et al. (SBP ≥135 or DBP ≥85 (24)). Prevalences were similar for men and women, and prevalences were slightly lower when using the wrist BP monitor to determine the presence of occult hypertension (Table 6). When participants taking antihypertensive medication were excluded from analysis, the prevalence of occult hypertension was slightly higher for men and slightly lower for women than in the total sample (Table 7).

Table 4. Psychological/psychosomatic distress (n=266)

	Hospital workers			Home care workers			Total		
	N	%		N	%		N	%	
Total	**239**	**100%**		**27**	**100%**		**266**	**100%**	
Depression:									
caseness (≥16)	25	10.5%		5	18.5%		30	11.3%	
missing	18	7.5%		7	25.9%		25	9.4%	
Anxiety:									
high	68	28.5%		8	29.6%		76	28.6%	
medium	94	39.3%		7	25.9%		101	38.0%	
low	72	30.1%		9	33.3%		81	30.5%	
missing	5	2.1%		3	11.1%		8	3.0%	
Insomnia:									
frequent symptoms	76	31.8%		8	29.6%		84	31.6%	
missing	4	1.7%		2	7.4%		6	2.3%	
Depression case, high anxiety or frequent insomnia	110	46.0%		15	55.6%		125	47.0%	
	N	**mean**	**s.d.**	**N**	**mean**	**s.d.**	**N**	**mean**	**s.d.**
Depression (0-80)	221	6.6	8.22	20	13.1	16.10	241	7.1	9.26
Anxiety (0-25)	234	9.8	5.42	24	10.4	5.85	258	9.9	5.45
Fatigue (0-11)	213	4.7	2.83	22	5.2	2.50	235	4.8	2.80

Table 5. Ambulatory, wrist and calibration blood pressure readings

	Hospital workers		Home care workers		Total	
	N	%	N	%	N	%
*Ambulatory BP: <120/80	67	40.6%	6	60.0%	73	41.7%
121/89-139-89	64	38.8%	2	20.0%	66	37.7%
140/90+	34	20.6%	2	20.0%	36	20.6%
Total: ABP readings ≥5	165	100%	10	100%	175	100%
#Wrist BP: <120/80	57	44.5%	3	50.0%	60	44.8%
121/89-139-89	40	31.3%	2	33.3%	42	31.3%
140/90+	31	24.2%	1	16.7%	32	23.9%
Total: wrist readings ≥5	128	100%	6	100%	134	100%
Calibration BP: <120/80	73	44.2%	3	33.3%	76	43.7%
121/89-139-89	59	35.8%	4	44.4%	63	36.2%
140/90+	33	20.0%	2	22.2%	35	13.2%
Total: calibration readings	165	100%	9	100%	174	100%
**Ambulatory–wrist work systolic within±5 mm Hg	47	41.2	3	75%	50	42.4%
**Ambulatory–wrist work diastolic within±5 mm Hg	61	53.5%	3	75%	64	54.2%
**Ambulatory–wrist work systolic within±10mmHg	81	71.1%	3	75%	84	71.2%
**Ambulatory–wrist work diastolic within±10mmHg	101	88.6%	3	75%	104	88.1%

	N	mean	s.d.	N	mean	s.d.	N	mean	s.d.
*Ambulatory work systolic	165	123.5	15.12	10	119.3	13.08	175	123.3	15.01
*Ambulatory work diastolic	165	79.7	10.03	10	15.7	12.51	175	79.5	10.18
Calibration systolic	165	123.6	17.47	9	125.0	10.49	174	123.7	17.16
Calibration diastolic	165	77.3	11.43	9	76.7	10.10	174	77.2	11.34
#Wrist work systolic	128	124.0	15.27	6	128.8	25.45	134	124.2	15.75
#Wrist work diastolic	128	78.3	10.57	6	79.57	17.37	134	78.31	10.86
**Ambulatory – wrist work systolic difference	114	-0.46	10.65	4	3.2	9.82	118	-0.34	10.60
**Ambulatory – wrist work diastolic difference	114	1.2	6.46	4	5.5	6.06	118	1.3	6.47

*Minimum of 5 ambulatory readings; **Minimum of 5 ambulatory and 5 wrist readings; # Minimum of 5 wrist readings

Table 6. Prevalence of occult hypertension, total sample			
Work blood pressure	**Prevalence**		**Work blood pressure cutpoints**
	%	N	
Ambulatory	19.4%	26/134	SBP ≥136 or DBP ≥87 (men) SBP ≥131 or DBP ≥86 (women) (57)
	20.1%	27/134	SBP ≥135 or DBP ≥85 (24, 32)
	4.5%	6/134	SBP ≥140 or DBP ≥90 (58)
Wrist	16.0%	15/94	SBP ≥136 or DBP ≥87 (men) SBP ≥131 or DBP ≥86 (women) (57)
	12.8%	12/94	SBP ≥135 or DBP ≥85 (24, 32)
	5.3%	5/94	SBP ≥140 or DBP ≥90 (58)
Men			
	%	N	
Ambulatory	16.7%	5/30	SBP ≥136 or DBP ≥87 (57)
	23.3%	7/30	SBP ≥135 or DBP ≥85 (24, 32)
	3.3%	1/30	SBP ≥140 or DBP ≥90 (58)
Wrist	15.4%	4/26	SBP ≥136 or DBP ≥87 (57)
	23.1%	6/26	SBP ≥135 or DBP ≥85 (24, 32)
	7.7%	2/26	SBP ≥140 or DBP ≥90 (58)
Women			
	%	N	
Ambulatory	20.2%	21/104	SBP ≥131 or DBP ≥86 (57)
	19.2%	20/104	SBP ≥135 or DBP ≥85 (24, 32)
	4.8%	5/104	SBP ≥140 or DBP ≥90 (58)
Wrist	16.2%	11/68	SBP ≥131 or DBP ≥86 (57)
	8.8%	6/68	SBP ≥135 or DBP ≥85 (24, 32)
	4.4%	3/68	SBP ≥140 or DBP ≥90 (58)

Note: n=134 with a minimum of 5 ambulatory work readings and calibration BP <140 systolic and <90 diastolic; n=94 with a minimum of 5 wrist work readings and calibration BP <140 systolic and <90 diastolic

Table 7. Prevalence of occult hypertension, excluding pregnant subjects and those taking antihypertensive medication (n=116)			
Work blood pressure	**Prevalence**		**Work blood pressure cutpoints**
	%	N	
Ambulatory	17.8%	18/101	SBP ≥136 or DBP ≥87 (men) SBP ≥131 or DBP ≥86 (women) (57)
	17.8%	18/101	SBP ≥135 or DBP ≥85 (24, 32)
	5.0%	5/101	SBP ≥140 or DBP ≥90 (58)
Wrist	16.9%	12/71	SBP ≥136 or DBP ≥87 (men) SBP ≥131 or DBP ≥86 (women) (57)
	15.5%	11/71	SBP ≥135 or DBP ≥85 (24, 32)
	5.6%	4/71	SBP ≥140 or DBP ≥90 (58)
Men			
	%	N	
Ambulatory	20.0%	5/25	SBP ≥136 or DBP ≥87 (57)
	24.0%	6/25	SBP ≥135 or DBP ≥85 (24, 32)
	4.0%	1/25	SBP ≥140 or DBP ≥90 (58)
Wrist	19.0%	4/21	SBP ≥136 or DBP ≥87 (57)
	28.6%	6/21	SBP ≥135 or DBP ≥85 (24, 32)
	9.5%	2/21	SBP ≥140 or DBP ≥90 (58)
Women			
	%	N	
Ambulatory	17.1%	13/76	SBP ≥131 or DBP ≥86 (57)
	15.8%	12/76	SBP ≥135 or DBP ≥85 (24, 32)
	5.3%	4/76	SBP ≥140 or DBP ≥90 (58)
Wrist	16.0%	8/50	SBP ≥131 or DBP ≥86 (57)
	10.0%	5/50	SBP ≥135 or DBP ≥85 (24, 32)
	4.0%	2/50	SBP ≥140 or DBP ≥90 (58)

Note: n=116 with a minimum of 5 ambulatory work readings and calibration BP; n=101 with a minimum of 5 ambulatory work readings and calibration BP <140 systolic and <90 diastolic; n=71 with a minimum of 5 wrist work readings and calibration BP <140 systolic and <90 diastolic

Associations between work hours, work stressors and ambulatory blood pressure

Longer work hours were not associated with higher levels of ABP (Table 8a). In fact, participants working more than 50 hours per week had 4.3 mm Hg lower ABP (ns) than the reference group (35-40 hours per week) in the fully adjusted Model III. This (non-significant) trend towards lower ABP when working longer hours was also observed when paid and home hours were combined, although the magnitudes were smaller

Modest associations were observed between job strain, effort-reward imbalance and shiftwork and systolic ABP (3-4 mm Hg). However, these associations reached the level of statistical significance only for shiftwork in Model I (Table 8a). In the fully adjusted Model III, the 40% (70/175) of participants facing the combination of job strain and effort-reward imbalance had systolic ABP 4.6 mm Hg higher (p=.06) than those without this combination of stressors.

Substantial and significant associations with ABP were observed for our primary measure of socioeconomic status, education. The systolic ABP of health care workers with only a high school education was 18.4 mm Hg higher (p<.001) than the reference group, those who had attended graduate school (Model III). Those with some college education also had significantly higher systolic ABP (10.4 mm Hg, p=.02) than the reference group. When job strain, effort-reward imbalance and shiftwork were combined into the same model with job category and education, education retained its substantial and significant association with systolic ABP, but none of the other exposures were associated with ABP.

Similar patterns were observed for diastolic ABP (Table 8b). The combination of job strain and effort-reward imbalance (3.1 mm Hg, p=.047) and shiftwork (4.5 mm Hg, p=.03) were significantly associated with diastolic ABP in Model I, but associations were no longer

Table 8a. Associations between ambulatory systolic blood pressure and measures of work organization and socioeconomic status (n=175)									
		Adjusted for age, gender, race/ethnicity		+ education, job physical demands, marital status, family hx of HTN, pregnancy, current use HTN meds		+ BMI, current smoker, alcoholic drinks/wk, leisure time exercise, diabetes		+ other job stressors (job strain, ERI, shift) and SES (job category, education)	
	N	mm Hg	p	mm Hg	p	mm Hg	p	mm Hg	p
Job strain	96	3.1	.18	2.7	.23	3.0	.20	0.9	.74
Effort/Reward >1	90	2.7	.23	4.0	.12	4.2	.10	4.4	.12
Job strain + E/R>1	70	4.1#	.08	4.4#	.07	4.6#	.06	--	--
Evening, night shift	29	6.3*	.04	4.1	.18	4.2	.18	3.9	.24
Paid hrs/wk:									
32 or less	6	10.6#	.09	5.9	.34	5.9	.35	--	--
35 to 40	133	Ref	--	ref	--	ref	--	--	--
40.5 to 48	24	0.1	.98	1.2	.70	1.0	.76	--	--
50+	12	-6.3	.16	-4.0	.36	-4.3	.34	--	--
Paid + home hrs/wk:									
<41.5	41	2.7	.37	3.2	.29	3.9	.20	--	--
41.5 to 47.9	55	Ref	--	ref	--	ref	--	--	--
48 to 60	53	-2.0	.48	-0.4	.89	0.2	.95	--	--
>60	26	-0.7	.85	1.1	.30	1.2	.73	--	--
Job category:									
Home care	10	-0.1	.99	-1.6	.81	0.7	.92	-1.2	.87
Service/Maintenance	20	6.8	.27	5.1	.40	5.7	.35	4.1	.51
Clerical	74	4.3	.43	3.1	.55	4.4	.41	3.1	.57
LPN	30	7.0	.24	3.1	.60	4.6	.44	3.1	.61
Technical	25	1.4	.81	3.0	.61	4.0	.50	1.7	.78
RN	7	-0.8	.91	4.8	.53	4.5	.56	5.6	.47
Paraprofessional	9	Ref	--	ref	--	ref	--	ref	--
Education:									
High school	51	17.3***	<.001	18.2***	<.001	18.4***	<.001	18.1***	.001
Some College	82	10.1*	.02	10.5*	.02	10.4*	.02	11.1*	.02
BA	26	2.8	.53	3.6	.44	2.7	.58	3.0	.55
Graduate School	16	Ref	--	ref	--	ref	--	ref	--
#p<.10, *p<.05, **p<.01, ***p<.001									

Table 8b. Associations between ambulatory diastolic blood pressure and measures of work organization and socioeconomic status (n=175)

	N	Adjusted for age, gender, race/ethnicity		+ education, job physical demands, marital status, family hx of HTN, pregnancy, current use HTN meds		+ BMI, current smoker, alcoholic drinks/wk, leisure time exercise, diabetes		+ other job stressors (job strain, ERI, shift) and SES (job category, education)	
	N	mm Hg	p	mm Hg	p	mm Hg	p	mm Hg	p
Job strain	96	2.5	.10	1.5	.33	1.5	.33	0.3	.88
Effort/Reward >1	90	2.6#	.09	1.8	.28	2.1	.21	2.6	.18
Job strain + E/R>1	70	3.1*	.047	2.0	.21	2.2	.19	--	--
Evening, night shift	29	4.5*	.03	2.7	.19	2.9	.17	2.6	.25
Paid hrs/wk:									
32 or less	6	7.1#	.095	3.4	.40	3.2	.45	--	--
35 to 40	133	ref	--	ref	--	ref	--	--	--
40.5 to 48	24	-1.0	.64	-0.4	.85	-0.4	.86	--	--
50+	12	-3.8	.21	-2.6	.38	-2.9	.33	--	--
Paid + home hrs/wk:									
<41.5	41	-0.1	.98	0.4	.84	0.7	.73	--	--
41.5 to 47.9	55	ref	--	ref	--	ref	--	--	--
48 to 60	53	-4.4*	.02	-3.5#	.07	-3.3#	.09	--	--
>60	26	-2.5	.30	-1.3	.58	-1.3	.59	--	--
Job category:									
Home care	10	0.3	.96	-2.6	.58	-2.5	.60	-3.8	.43
Service/Maintenance	20	4.1	.33	2.5	.54	2.4	.56	1.1	.80
Clerical	74	3.4	.34	2.9	.40	2.8	.43	1.9	.61
LPN	30	7.4#	.07	3.7	.35	4.1	.31	2.7	.51
Technical	25	2.9	.48	4.4	.26	3.6	.37	2.0	.62
RN	7	3.6	.48	6.3	.21	5.3	.31	5.8	.27
Paraprofessional	9	ref	--	ref	--	ref	--	ref	--
Education:									
High school	51	11.9***	.001	11.4***	<.001	12.1***	<.001	12.6***	.001
Some College	82	6.0*	.04	5.5	.06#	5.9	.06#	7.0*	.03
BA	26	1.5	.63	1.2	.71	0.9	.77	1.1	.75
Graduate School	16	ref	--	ref	--	ref	--	ref	--

#p<.10, *p<.05, **p<.01, ***p<.001

significant in the fully adjusted Model III. Participants with high school education had diastolic ABP 12.1 mm Hg higher (p<.001) than those with graduate education.

When the sample was restricted to women (n=133), similar patterns were observed for work hours, job category and education (data not shown). However, associations between ABP and job stressors were of a larger magnitude. In the fully adjusted Model III, the ABP of women with job strain was 4.8 mm Hg systolic (p=.08) and 3.2 mm Hg diastolic (p=.08) higher than women not reporting job strain. Similarly, the ABP of women with effort-reward imbalance was 6.5 mm Hg systolic (p=.03) and 4.3 mm Hg diastolic (p=.03) higher than women not reporting effort-reward imbalance. The ABP of women with both job strain and effort-reward imbalance was 6.6 mm Hg systolic (p=.02) and 4.0 mm Hg diastolic (p=.04) higher than women not reporting either stressor. However, shiftwork among women was not significantly associated with ABP. Effort-reward imbalance retained a significant association with systolic ABP (6.0 mm Hg, p=.06) and diastolic ABP (4.2 mm Hg, p=.046) when adjusted also for job strain and shiftwork.

Interactions between job stressors and education. None of the six interaction terms between work exposures and education were significant at p<.05 for either systolic ABP (Table 9a) or diastolic ABP (Table 9b). However, a pattern of interaction for systolic ABP was observed for job strain, effort-reward imbalance, the combination of job strain and effort-reward imbalance, and work hours ≥41/wk. Among those with a high school education, associations with systolic ABP were of the following magnitudes: job strain (6.0 mm Hg) (interaction term, p=.07, adjusted for age, race, gender, p=.11, full model), effort-reward imbalance (8.6 mm Hg), job strain and effort-reward imbalance (10.2 mm Hg) and work hours ≥41/week (8.7 mm Hg). For employees with higher levels of education, associations between these stressors and systolic

Table 9a. Associations between ambulatory systolic blood pressure and combined measures of work organization and education (n=175)							
	N	mm Hg	p	N	mm Hg	p	Effect of stressor at each stratum
Education level	**Job strain**			**No job strain**			
High school	30	18.50***	<.001	21	12.52*	.01	5.98
Some college	44	9.07*	.03	38	6.83	.11	2.24
College graduate	22	-1.00	.83	20	ref	--	-1.00
	Effort/Reward>1			**Effort/Reward<=1**			
High school	25	23.10***	<.001	26	14.46**	.003	8.64
Some college	42	11.30*	.013	40	9.58*	.027	1.72
College graduate	23	3.94	.39	19	ref	--	3.94
	Job strain + E/R>1			**No job strain or E/R≤1**			
High school	18	24.94***	<.001	33	14.70**	.001	10.24
Some college	36	11.39**	.006	46	9.49*	.016	1.90
College graduate	16	5.61	.24	26	ref	--	5.61
	Shiftwork			**No shiftwork**			
High school	17	19.65***	<.001	34	15.58***	<.001	4.07
Some college	7	13.38*	.038	75	8.63*	.011	4.75
College graduate	5	2.63	.71	37	ref	--	2.63
	Work hrs ≥41/wk			**Work hrs <41/wk**			
High school	7	23.34***	<.001	44	14.64***	<.001	8.70
Some college	12	3.36	.532	70	8.96*	.015	-5.60
College graduate	15	-0.69	.881	27	ref	--	-0.69
	Work+home hrs ≥57.5/wk			**Work+home hrs <57.5/wk**			
High school	6	13.28	.051	45	18.12***	<.001	-4.84
Some college	22	10.53*	.018	60	9.23*	.016	1.30
College graduate	12	3.21	.531	30	ref	--	3.21

#p<.10, *p<.05, **p<.01, ***p<.001

Multiplicative interaction terms, p<.10: job strain and education, adjusted for age, race, gender, p=.07 (full model, p=.11).

Adjusted for age, gender, race/ethnicity, physical job demands, marital status, family history of hypertension, pregnancy, current use of medication for hypertension, BMI, current smoker, alcoholic drinks/wk; leisure time exercise, and diabetes.

Table 9b. Associations between ambulatory diastolic blood pressure and combined measures of work organization and education (n=175)							
	N	mm Hg	p	N	mm Hg	p	Effect of stressor at each stratum
	Job strain			No job strain			
High school	30	11.91***	<.001	21	9.98**	.003	1.93
Some college	44	5.74*	.042	38	3.81	.19	1.93
College graduate	22	-0.61	.85	20	ref	--	-0.61
	Effort/reward>1			Effort/reward<=1			
High school	25	15.69***	<.001	26	10.58**	.001	5.11
Some college	42	6.66*	.029	40	6.74*	.021	-0.08
College graduate	23	3.05	.33	19	ref	--	3.05
	Job strain + E/R>1			No job strain or E/R≤1			
High school	18	15.75***	<.001	33	10.87***	<.001	4.88
Some college	36	6.86*	.014	46	5.90*	.028	0.96
College graduate	16	3.42	.29	26	ref	--	3.42
	Shiftwork			No shiftwork			
High school	17	12.56***	<.001	34	11.90***	<.001	0.66
Some college	7	9.62*	.027	75	5.53*	.015	4.09
College graduate	5	4.80	.31	37	ref	--	4.80
	Work hrs ≥41/wk			Work hrs <41/wk			
High school	7	15.72***	<.001	44	10.47***	<.001	5.25
Some college	12	-0.22	.95	70	6.14*	.013	-6.36
College graduate	15	.57	.85	27	ref	--	0.57
	Work+home hrs ≥57.5/wk			Work+home hrs <57.5/wk			
High school	6	4.95	.27	45	13.45***	<.001	-8.50
Some college	22	6.73*	.023	60	5.93*	.020	0.80
College graduate	12	2.70	.43	30	ref	--	2.70
#p<.10, *p<.05, **p<.01, ***p<.001							
Multiplicative interaction terms, p<.10: total hours ≥57.5/wk and education, adjusted for age, race, gender, p=.07, full model, p=.06.							
Adjusted for age, gender, race/ethnicity, physical job demands, marital status, family history of hypertension, pregnancy, current use of medication for hypertension, BMI, current smoker, alcoholic drinks/wk, leisure time exercise, and diabetes.							

ABP were much lower. These results suggest that statistically significant interactions would be observed if the sample size was larger. The pattern of interaction was less evident for diastolic blood pressure.

Interactions between work hours and job stressors. One interaction term between long work hours and a job stressor was significant for systolic ABP (total hours ≥57.5/wk and effort/reward>1, p=.04, adjusted for age, race, gender, p=.14, full model). However, the direction of the interaction was the opposite of that hypothesized (Table 9c). Two interaction terms between long work hours and job stressors were significant for diastolic ABP (total hours ≥57.5/wk and effort/reward>1, p=.02, adjusted for age, race, gender, p=.12, full model; total hours ≥57.5/wk and job strain, p=.05, adjusted for age, race, gender, p=.27 full model). However, the direction of these interactions was also the opposite of that hypothesized (Table 9d). Long work hours were associated with lower ABP (with some exceptions) whether employees were facing job strain or effort-reward imbalance or not.

Table 9c. Associations between ambulatory systolic blood pressure and combined measures of work organization and education (n=175)							
	N	mm Hg	p	N	mm Hg	p	Effect of stressor at each stratum
	Work hrs ≥41/wk			Work hrs <41/wk			
Job strain	20	0.78	.85	76	3.78	.16	-3.00
No job strain	14	-1.91	.67	65	ref	--	-1.91
Effort/Reward>1	23	-0.33	.93	67	5.48#	.065	-5.81
No Effort/Reward>1	11	1.62	.75	74	ref	--	1.62
	Work+home hrs ≥57.5/wk			Work+home hrs <57.5/wk			
Job strain	23	2.78	.48	73	4.67	.10	-1.89
No job strain	17	2.81	.53	62	ref	--	2.81
Effort/Reward>1	25	1.01	.79	65	6.24*	.036	-5.23
No Effort/Reward>1	15	6.54	.15	70	ref	--	6.54

#p<.10, *p<.05, **p<.01, ***p<.001

Multiplicative interaction terms, p<.10: total hours ≥57.5/wk and effort/reward>1, adjusted for age, race, gender, p=.04 (full model, p=.14).

Adjusted for age, gender, race/ethnicity, physical job demands, marital status, family history of hypertension, pregnancy, current use of medication for hypertension, BMI, current smoker, alcoholic drinks/wk, leisure time exercise, and diabetes.

Table 9d. Associations between ambulatory diastolic blood pressure and combined measures of work organization and education (n=175)							
	N	mm Hg	p	N	mm Hg	p	Effect of stressor at each stratum
	Work hrs ≥41/wk			Work hrs <41/wk			
Job strain	20	0.37	.99	76	1.56	.39	-1.19
No job strain	14	-3.57	.24	65	ref	--	-3.57
Effort/Reward>1	23	-0.97	.71	67	2.57	.20	-3.74
No Effort/Reward>1	11	-1.19	.73	74	ref	--	-1.19
	Work+home hrs ≥57.5/wk			Work+home hrs <57.5/wk			
Job strain	23	0.11	.97	73	3.22#	.09	-3.11
No job strain	17	2.33	.44	62	ref	--	2.33
Effort/Reward>1	25	-0.23	.75	65	3.65#	.07	-3.88
No Effort/Reward>1	15	3.82	.21	70	ref	--	3.82

#p<.10, *p<.05, **p<.01, ***p<.001

Multiplicative interaction terms, p<.10: total hours ≥57.5/wk and education, adjusted for age, race, gender, p=.07, full model, p=.06; total hours ≥57.5/wk and job strain, adjusted for age, race, gender, p=.05 (full model, p=.27); total hours ≥57.5/wk and effort/reward>1, adjusted for age, race, gender, p=.02 (full model, p=.12) .

Adjusted for age, gender, race/ethnicity, physical job demands, marital status, family history of hypertension, pregnancy, current use of medication for hypertension, BMI, current smoker, alcoholic drinks/wk, leisure time exercise, and diabetes.

Occult hypertension

Modest elevations of risk of occult hypertension in the range of odds ratio of 1.5-2.0 were observed for job strain and the combination of job strain and effort-reward imbalance for some definitions (Table 10). Work hours tended to be associated with reduced risk. However, perhaps in part due to the low prevalence of occult hypertension, none of these associations reached the level of statistical significance. On the other hand, associations between shiftwork and occult hypertension were substantially elevated for all three definitions, and was significantly associated with occult hypertension using the definition of Pierdomenico et al (24), both in Model I (OR=3.16, 95% CI 1.06-9.44) and in the fully adjusted Model (OR=3.62, 95% CI 1.05-12.45). When employees who were pregnant or on medication for hypertension were excluded from analyses, magnitudes of association for shiftwork, the combination of job strain and effort-reward imbalance, and education were larger than in the overall sample (Table 11). Shiftwork was significantly associated with occult hypertension in Model I for the definition of Verdecchia et al (57) (OR=4.61, 95% CI 1.07-19.87) and for the definition of Pierdomenico et al (24) (OR=6.91, 95% CI 1.59-29.99) and in the fully adjusted model for the definition of Pierdomenico et al (24) (OR=5.61, 95% CI 1.03-30.57).

Table 10. Work organization and socioeconomic predictors of occult hypertension (n=164)

	Adjusted for age, gender, race/ethnicity			+ education, physical job demands, marital status, family hx HTN, current use HTN meds, pregnancy, BMI, current smoker, alcoholic drinks/wk, leisure time exercise, diabetes			Definition of occult HTN (if calibration SBP <140 or DBP <90)
	OR	95% CI	p	OR	95% CI	p	
Job strain	1.36	0.56-3.31	.51	1.46	0.53-4.04	.47	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.68	0.68-4.18	.26	1.69	0.63-4.53	.30	SBP ≥135 or DBP ≥85
	0.63	0.11-3.56	.60	0.83	0.11-6.60	.86	SBP ≥140 or DBP ≥90
Effort/reward>1	0.87	0.36-2.09	.76	1.20	0.40-3.66	.75	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.09	0.45-2.61	.85	1.28	0.43-3.80	.85	SBP ≥135 or DBP ≥85
	1.68	0.28-9.99	.57	2.87	0.23-35.26	.41	SBP ≥140 or DBP ≥90
Job strain + E/R>1	1.17	0.48-2.85	.74	1.49	0.50-4.47	.47	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.76	0.73-4.25	.21	2.12	0.74-6.09	.17	SBP ≥135 or DBP ≥85
	1.40	0.26-7.71	.70	2.43	0.21-27.80	.48	SBP ≥140 or DBP ≥90
Evening, night, rotating shiftwork	2.11	0.68-6.52	.20	2.57	0.67-9.86	.17	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	3.16*	1.06-9.44	.04	3.62*	1.05-12.45	.04	SBP ≥135 or DBP ≥85
	5.92	0.72-48.42	.10	6.81	0.34-135.67	.21	SBP ≥140 or DBP ≥90
Work hrs ≥41/wk	0.72	0.22-2.32	.59	0.58	0.15-2.18	.42	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	0.69	0.21-2.25	.54	0.66	0.19-2.38	.53	SBP ≥135 or DBP ≥85
	0.69	0.07-6.62	.74	0.36	0.02-7.03	.50	SBP ≥140 or DBP ≥90
Work+home hrs ≥57.5/wk	1.42	0.52-3.88	.49	0.90	0.28-2.91	.86	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.17	0.42-3.20	.77	0.74	0.24-2.35	.61	SBP ≥135 or DBP ≥85
	1.76	0.28-11.03	.55	1.21	0.10-14.56	.88	SBP ≥140 or DBP ≥90
Education (≤12 yrs vs >12 yrs)	1.32	0.50-3.48	.58	2.19	0.73-6.63	.16	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	0.87	0.32-2.42	.79	1.08	0.36-3.25	.89	SBP ≥135 or DBP ≥85
	0.57	0.06-5.84	.64	0.98	0.06-16.80	.99	SBP ≥140 or DBP ≥90

#p<.10, *p<.05, **p<.01, ***p<.001

Note: Other predictors, p<.10: Definition 1, full model: "Asian + other" race (5/16, 31.3% vs. 26/164, 15.9%), OR=7.04 (1.01-48.83); HTN meds, OR=0.11 (0.02-0.59); BMI, OR=0.90 (0.79-1.02) (p=.08); pregnancy, OR=3.93 (0.85-181.10) (p=.08); alcoholic drinks/wk, OR=1.25 (0.96-1.62) (p=.098).
Definition 2, full model: "Asian + other" race; HTN meds
Definition 3, full model: none

Table 11. Work organization and socioeconomic predictors of occult hypertension (excluding if pregnant or on medication for hypertension) (n=116)							
	Adjusted for age, gender, race/ethnicity			+ education, physical job demands, marital status, family hx HTN, current use HTN meds, pregnancy, BMI, current smoker, alcoholic drinks/wk, leisure time exercise, diabetes			Definition of occult HTN (if calibration SBP <140 or DBP <90)
	OR	95% CI	p	OR	95% CI	p	
Job strain	1.20	0.41-3.51	.74	1.09	0.29-4.14	.90	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.96	0.64-6.00	.24	1.74	0.43-7.08	.44	SBP ≥135 or DBP ≥85
	1.11	0.16-7.80	.92	1.15	0.12-10.73	.90	SBP ≥140 or DBP ≥90
Effort/reward>1	0.90	0.31-2.63	.85	1.13	0.27-4.72	.87	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.57	0.53-4.67	.42	1.64	0.37-7.38	.52	SBP ≥135 or DBP ≥85
	1.56	0.23-10.40	.65	2.31	0.16-33.94	.54	SBP ≥140 or DBP ≥90
Job strain + E/R>1	1.19	0.40-3.57	.76	1.31	0.30-5.71	.72	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	2.61#	0.87-7.82	.09	3.15	0.67-14.93	.15	SBP ≥135 or DBP ≥85
	2.44	0.36-16.58	.36	4.86	0.27-86.72	.28	SBP ≥140 or DBP ≥90
Evening, night, rotating shiftwork	4.61*	1.07-19.87	.04	3.78	0.69-20.78	.13	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	6.91*	1.59-29.99	.01	5.61*	1.03-30.57	.046	SBP ≥135 or DBP ≥85
	5.52	0.28-107.74	.26	2.30	0.07-79.75	.65	SBP ≥140 or DBP ≥90
Work hrs ≥41/wk	.51	0.10-2.52	.41	0.34	0.06-1.93	.22	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	.49	0.10-2.45	.39	0.45	0.08-2.55	.37	SBP ≥135 or DBP ≥85
	.00	--	--	.00	--	--	SBP ≥140 or DBP ≥90
Work+home hrs ≥57.5/wk	0.95	0.27-3.36	.94	0.73	0.18-3.01	.67	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.16	0.35-3.88	.81	0.89	0.23-3.53	.87	SBP ≥135 or DBP ≥85
	0.83	0.08-8.59	.88	0.93	0.06-14.44	.96	SBP ≥140 or DBP ≥90
Education (≤12 yrs vs >12 yrs)	2.17	0.66-7.10	.20	3.11	0.78-12.47	.11	SBP ≥136 or DBP ≥87 (m) SBP ≥131 or DBP ≥86 (w)
	1.35	0.39-4.75	.64	1.97	0.47-8.25	.36	SBP ≥135 or DBP ≥85
	0.93	0.08-10.58	.95	1.61	0.10-26.90	.74	SBP ≥140 or DBP ≥90

#p<.10, *p<.05, **p<.01, ***p<.001

Note: Other predictors, p<.10: Definition 1, full model: Age, OR=1.05 (0.99-1.10) (p=.097); BMI, OR=0.87 (0.75-1.03) (p=.099).
Definition 2, full model: Alcoholic drinks/wk, OR=1.35 (0.96-1.90) (p=.085).
Definition 3, full model: none

Psychological/psychosomatic distress

Several work stressors and work hour variables were significantly associated with measures of psychological/psychosomatic distress. Work plus home hours ≥57.5/week were associated with depression both for Model I (OR=3.57, 95% CI 1.61-7.93) and for the fully adjusted Model (OR=4.34, 95% CI 1.80-10.47) (Table 12).

Effort-reward imbalance was associated with high levels of anxiety both in Model I (OR=2.77, 95% CI 1.50-5.00) and the fully adjusted Model (OR=2.70, 95% CI 1.47-4.95) (Table 13). Having only a high school education was associated with reduced risk of reporting high anxiety both in Model I Education (OR=0.34, 95% CI 0.16-0.72) and in the fully adjusted Model (OR=0.30, 95% CI 0.14-0.65).

The association between insomnia and job strain and effort-reward imbalance was modest and significant only at the $p<.10$ level of significance (Table 14). The association of job strain and insomnia was OR=1.64, 95% CI 0.94-2.86 (Model I) and OR=1.64, 95% CI 0.93-2.90 (in the fully adjusted model. The association of effort-reward imbalance and insomnia was OR=1.65, 95% CI 0.96-2.86 (Model I) and OR=1.69, 95% CI 0.97-2.95 (in the fully adjusted Model).

The combined measure of psychological/psychosomatic distress (either depression, or high anxiety or insomnia) was associated with effort-reward imbalance in Model I (OR=2.25, 95% CI 1.35-3.75) and in the fully adjusted Model (OR=2.28, 95% CI 1.36-3.84). Distress was also associated with the combination of job strain and effort-reward imbalance in Model I (OR=1.72, 95% CI 1.04-2.87) and in the fully adjusted Model OR=1.70, 95% CI 1.01-2.85).

Finally, the continuous measure of fatigue (need for recovery after work) was significantly associated job strain, effort-reward imbalance, the combination of job strain and effort-reward imbalance, work hours ≥41/wk and work + home hours ≥57.5/week (Table 16).

Table 12. Work organization and socioeconomic predictors of depression (n=241)						
	Adjusted for age, gender, race/ethnicity			+ education, marital status, pregnancy, BMI, current smoker, alcoholic drinks/wk, leisure time exercise		
	OR	**95% CI**	**p**	**OR**	**95% CI**	**p**
Job strain	1.50	0.66-3.38	.33	1.55	0.67-3.63	.31
Effort/reward>1	1.60	0.70-3.61	.26	1.60	0.69-3.67	.27
Job strain + Effort/reward>1	1.47	0.67-3.24	.34	1.51	0.66-3.44	.33
Shiftwork	1.18	0.48-2.91	.71	1.34	0.51-3.50	.55
Work hrs ≥41/wk	0.88	0.33-2.34	.80	0.80	0.93-2.21	.67
Work + home hrs ≥57.5/wk	3.57**	1.61-7.93	.002	4.34**	1.80-10.47	.001
Education (≤12 vs >12 yrs)	0.42	0.14-1.30	.13	0.42	0.13-1.33	.14

#p<.10, *p<.05, **p<.01, ***p<.001

Definition: CES-D-rev ≥16 (48). Prevalence of depression = 11.3% (30/241).
No demographic or biomedical predictors of depression significant at p<.10.

Table 13. Work organization and socioeconomic predictors of anxiety (n=258)						
	Adjusted for age, gender, race/ethnicity			+ education, marital status, pregnancy, BMI, current smoker, alcoholic drinks/wk, leisure time exercise		
	OR	**95% CI**	**p**	**OR**	**95% CI**	**p**
Job strain	1.52	0.85-2.72	.16	1.54	0.85-2.79	.15
Effort/reward>1	2.77**	1.50-5.00	.001	2.70**	1.47-4.95	.001
Job strain + Effort/reward>1	1.87*	1.06-3.29	.03	1.88*	1.06-3.34	.03
Shiftwork	1.11	0.57-2.14	.76	1.13	0.57-2.24	.72
Work hrs ≥41/wk	1.10	0.60-2.15	.79	1.09	0.52-2.10	.89
Work + home hrs ≥57.5/wk	1.22	0.66-2.26	.52	1.36	0.72-2.59	.35
Education (≤12 vs >12 yrs)	0.34**	0.16-0.72	.005	0.30**	0.14-0.65	.002

#p<.10, *p<.05, **p<.01, ***p<.001

Definition: ≥13 on the Relaxed vs. Anxious scale from the General Well-Being Schedule (50).
Prevalence of high anxiety = 29.5% (76/258).
The only demographic or biomedical predictor of anxiety significant at p<.10 was age: fully adjusted OR=0.96 (0.94-0.99) (p=.005).

Table 14. Work organization and socioeconomic predictors of insomnia (n=259)

	Adjusted for age, gender, race/ethnicity			+ education, marital status, pregnancy, BMI, current smoker, alcoholic drinks/wk, leisure time exercise		
	OR	95% CI	p	OR	95% CI	p
Job strain	1.64#	0.94-2.86	.08	1.64#	0.93-2.90	.09
Effort/reward>1	1.65#	0.96-2.86	.07	1.69#	0.97-2.95	.07
Job strain + Effort/reward>1	1.53	0.89-2.62	.13	1.55	0.89-2.71	.12
Shiftwork	1.25	0.67-2.34	.46	1.15	0.60-2.21	.67
Work hrs ≥41/wk	1.15	0.61-1.03	.67	1.34	0.68-2.62	.40
Work + home hrs ≥57.5/wk	1.02	0.56-1.85	.95	1.30	0.69-2.46	.42
Education (≤12 vs >12 yrs)	1.09	0.59-1.99	.79	0.99	0.53-1.87	.99

#p<.10, *p<.05, **p<.01, ***p<.001

Definition: response of "often (5-15/month)" or "almost always (16-30/month)" to any of the following questions from the Sleep Heart Health Study: "have trouble falling asleep", "wake up during the night and have difficulty getting back to sleep", "wake up too early in the morning and be unable to get back to sleep" or "take sleeping pills or other medication to help you sleep" (51). Prevalence of insomnia = 32.4% (84/259).

The only demographic or biomedical predictor of insomnia significant at p<.10 was pregnancy: fully adjusted OR=0.35 (0.11-1.11) (p=.075).

Table 15. Work organization and socioeconomic predictors of psychological/ psychosomatic distress (n=266)

	Adjusted for age, gender, race/ethnicity			+ education, marital status, pregnancy, BMI, current smoker, alcoholic drinks/wk, leisure time exercise		
	OR	95% CI	p	OR	95% CI	p
Job strain	1.57#	0.95-2.62	.08	1.51	0.90-2.54	.12
Effort/reward>1	2.25**	1.35-3.75	.002	2.28**	1.36-3.84	.002
Job strain + Effort/reward>1	1.72*	1.04-2.87	.037	1.70*	1.01-2.85	.045
Shiftwork	1.27	0.71-2.28	.43	1.30	0.70-2.39	.40
Work hrs ≥41/wk	1.28	0.69-2.36	.44	1.37	0.72-2.60	.34
Work + home hrs ≥57.5/wk	1.31	0.75-2.28	.35	1.44	0.80-2.60	.22
Education (≤12 vs >12 yrs)	0.72	0.40-1.28	.26	0.70	0.38-1.27	.24

#p<.10, *p<.05, **p<.01, ***p<.001

Met definitions for depression caseness (48) or high anxiety (50) or insomnia (51). Prevalence of distress = 47.0% (125/266).

The only demographic or biomedical predictor of psychological/psychosomatic distress significant at p<.10 was age: fully adjusted OR=0.97 (0.95-0.995) (p=.02).

Table 16. Work organization and socioeconomic predictors of fatigue (n=235)					
		Adjusted for age, gender, race/ethnicity		+ education, marital status, pregnancy, BMI, current smoker, alcoholic drinks/wk, leisure time exercise	
	N	B	p	B	p
Job strain	133	1.21**	.001	1.20**	.001
Effort/reward>1	134	2.09***	<.001	2.08***	<.001
Job strain + Effort/reward>1	100	1.55***	<.001	1.56***	<.001
Shiftwork	58	0.30	.49	0.14	.75
Work hrs ≥41/wk	50	1.02*	.02	0.99*	.03
Work + home hrs ≥57.5/wk	64	0.77#	.06	0.89*	.04
Education (≤12 vs >12 yrs)	65	-0.09	.97	-0.77	.25

#p<.10, *p<.05, **p<.01, ***p<.001

Definition: Sum of 11 yes/no items on "need for recovery" after work (52). Possible range of scores, 0-11, mean=4.8, standard deviation=2.80. The only demographic or biomedical predictor of fatigue significant at p<.10 was age: fully adjusted B=-0.045 (-0.077 - -0.013) (p=.006).

Associations between exposure measures and health outcomes are summarized in Table 17.

Working conditions (from open-ended questions in questionnaire)

Additional details about working conditions and recommendations for improving conditions are provided by study participants' answers to open ended questions such as "What is the best part of your job?", "What is the most difficult aspect of your job?" and "What are some actions that could be taken to improve working conditions at your current job?" (Appendix A).

For example, 105 participants described "Satisfaction in Being a Caregiver/Helping Patients, Clients, Students", 45 described "Satisfaction Working with Co-Workers", 37 described that the job provided "Fulfillment of Career Interests or Goals", and 21 described enjoying the "Autonomy/Flexibility on the Job". On the other hand, 57 participants described "Overwhelming Demands (being understaffed)", 37 described "Difficulty with Colleagues/Lack of teamwork", 29 described "Difficulty with patients/family members/customers", and 22 described "Lack of organization on the job".

The following recommendations for improving working conditions were also described by the study participants: improvements in "Physical Condition of Work Environment/Condition of Equipment" (described by n=50), "Increased Staff" (n=48), better "Teamwork/Work Organization" (n=44) and "More Respect from Supervisors/Better Supervision" (n=29).

Table 17. Summary of study results: Fully adjusted associations between work hours, work stressors, socioeconomic status, blood pressure, occult hypertension and psychological/psychosomatic distress

	Sys ABP	Dias ABP	Occult HTN	Depress-ion	Anxiety	Insomnia	Dis-tress	Fatigue
Main effects:	@	@						
Job strain	0	0	0	0	0	+	0	+
Effort/reward>1	0	0	0	0	+	+	+	+
Job strain + Effort/reward>1	+	0	0	0	+	0	+	+
Shiftwork	0	0	+	0	0	0	0	0
Work hrs ≥41/wk	0	0	0	0	0	0	0	+
Work + home hrs ≥57.5/wk	0	0	0	+	0	0	0	+
Job category	0	0						
Education (≤12 vs >12 yrs)	++	++	0	0	-	0	0	0
Interactions (ABP):								
Job strain x low education	+	0						
E/R>1 x low education	+	0						
Job strain+E/R>1 x low educ	+	0						
Shiftwork x low educ	0	0						
Work hrs ≥41/wk x low educ	+	+						
Work+home hrs ≥57.5/wk x low educ	0	0						
Work hrs ≥41/wk x job strain	0	0						
Work hrs ≥41/wk x E/R>1	-	0						
Work+home hrs ≥57.5/wk x job strain	0	0						
Work+home hrs ≥57.5/wk x E/R>1	-	-						

++strong positive association; +positive association (p<.10); 0 no association; - inverse association (p<.10); -- strong inverse association

@In analyses restricted to women workers, positive associations were seen between systolic and diastolic ABP and job strain, effort-reward imbalance, both job strain and effort-reward imbalance, and high school education.

DISCUSSION

Ambulatory blood pressure

Long work hours. This study did not find an association between long work hours and BP elevation. In fact, participants working long hours (either paid work hours or paid work plus home hours) had slightly lower BP than the reference group (35-40 hours paid work per week or 41.5-47.9 paid work plus home hours per week). One possible explanation is the healthy worker effect for those working longer hours, suggested by BP elevations in those working part-time (32 hours or less). Education was associated with paid work hours ($r=.25$, $p=.001$, $n=175$) and paid work plus home hours ($r=.21$, $p=.006$, $n=175$) and lower BP. However, inverse associations between work hours and BP were also observed in models not controlling for education. This study was not designed to assess such a selection bias or possible interaction between work hours and education, since the total sample size was not large, and only 7% (12/175) of the participants in ABP analyses worked 50+ hours per week. Half of the 12 participants working 50+ hours per week had completed college, and only two had a high school diploma. Nonetheless, when paid work hours were dichotomized at ≥41 (vs. <41) per week, a substantial association of overtime with ABP among those with only high school education was observed (8.7 mm Hg systolic, 5.3 mm Hg diastolic), compared to no association or an inverse association among those with higher levels of education (interaction term, $p>.10$). However, a stronger association among employees with high school education was not observed for long paid work plus home hours. Nor was a stronger effect of work hours observed among employees facing job strain or effort-reward imbalance. Such interaction effects would likely be sensitive to cutpoints chosen for long work hours, which, in these tests of interactions, were chosen based on the distribution of hours in the sample, not based on a threshold of weekly hours (e.g., >50) presumed to have effects on BP.

This is the first study to test an interaction between work hours and SES on BP.

Socioeconomic status. The strong dose-response relationship between decreasing education and increasing ABP in this sample could not be explained by other variables. Controlling for demographic, biomedical, and job stressor variables caused little change in the substantial association between ABP and lower education levels. The 18 mm Hg systolic BP difference between workers with high school and graduate education in this study is far greater than population differences that are usually only about 2-3 mm Hg between the highest and lowest SES groups (59).

Work stressors. Associations between job strain, effort-reward imbalance, shiftwork, and ABP were modest and reached statistical significance only in models adjusted for age, race, and gender (and not education). In analyses restricted to women (76% of the sample with ABP readings), associations were stronger for job strain and effort-reward imbalance, in the range of 4.8-6.6 mm Hg systolic and 3.2-4.3 mm Hg diastolic. These effect estimates are similar in magnitude to the four (of six) ABP studies in women that found effects of job strain (14) and to effects observed among men facing job strain in the New York City WSBPS (15, 42). Shiftwork, which was more common among men in this sample, was no longer significantly associated with ABP after restricting the sample to women. Stronger effects of job strain and effort-reward imbalance were observed among workers with only a high school education (range 6-10 mm Hg systolic and 2-5 mm Hg diastolic) than among workers with higher education (interaction terms, job strain and education, systolic ABP, $p=.07$, adjusted for age, race, gender, $p=.11$, full model; job strain and education, diastolic ABP, and effort-reward imbalance and education, $p>.10$), consistent with two previous job strain studies (17, 60). This is the first study to assess interactions between effort-reward imbalance and SES on BP.

BP effects seen in this study are also clinically significant. An elevation of 8–10 mmHg in systolic blood pressure is associated with a 20–25% increased risk of coronary heart disease mortality and a 34–43% increased risk of stroke mortality (61).

Occult hypertension

The prevalence of occult hypertension in the current study (16-23% in men and 19-20% in women) was similar to other studies using two of the common definitions of occult hypertension (24, 32, 57). Prevalence was lower (3.3% for men and 4.5% for women) using a more restrictive definition (58). Its prevalence in the U.S. general population could be as high as 10% (28). Confounding did not appear to be a major issue. The prevalence of occult hypertension was similar after excluding participants who were pregnant or using antihypertensive medication.

The current study was not designed to answer the question of what is the most valid definition of occult hypertension. Further research on sequelae of occult hypertension, including CVD, will be needed to adequately answer that question. Since ABP is a necessary component of the definition of occult hypertension, one issue is the time period covered by ABP monitoring. The current study analyzed data on ABP only during work hours. Only 22 participants had ≥5 home ABP readings, thus, home ABP was not analyzed. Other studies that provided definitions of occult hypertension used either mean 24-hour ABP (including the most restrictive definition (58) and Verdecchia et al. (57)) or mean daytime (work and home) ABP (24, 32). There is currently no accepted definition for high ABP during work.

The current study found associations between occult hypertension and age and alcohol use, consistent with other studies (24, 31, 32). However, we did not find significant (p<.10) associations between occult hypertension and male gender or cigarette smoking as in other studies (24, 31, 32). These null results were perhaps due to limited statistical power since the sample size in the current study was much smaller than the other studies. The current study did not ask questions about coffee intake, which was associated with occult hypertension in the study by Pierdomenico et al. (24). The current study found a modest (p=.08) inverse association between BMI and occult hypertension, which has not been previously reported.

This was only the second study to examine predictors of occult hypertension in the work environment. We found that evening, night or rotating shiftwork was significantly associated with occult hypertension. At least a doubling of risk due to shiftwork was seen for all models and definitions of occult hypertension. Long work hours were not associated with occult hypertension consistent with its inverse association with ABP in this study. Modest elevations of risk due to job strain or effort-reward imbalance primarily in the range of 1.5-2.5 were observed. However only the combination of job strain and effort-reward imbalance for Model I, and excluding participants who were pregnant or on medication for hypertension, produced a risk estimate significant at the p<.10 level. These results are consistent with unpublished data from the New York City WSBPS. In the WSBPS, the prevalence of occult hypertension was 27.8% (10/36) for participants exposed to job strain, and 17.9% (26/145) if no job strain exposure -- a prevalence ratio of 1.55 (95% CI 0.82-2.91).

While rarely studied, occult hypertension is of major clinical significance. Because people with occult hypertension have a significantly increased risk of developing CVD compared to normotensives (24, 27), they require counseling, possibly treatment, and workplace stressor assessment, but rarely receive these because their office BP appears normal. The current study suggests that employees exposed to shiftwork, job strain, and effort-reward imbalance in particular need targeted ABP monitoring to determine whether they have occult hypertension.

Psychological/psychosomatic outcomes

This is the first study to examine the association between long work hours and fatigue, as measured by Sluiter et al's "need for recovery" scale (52), finding a significant association. Long work plus home hours were associated with a substantially increased risk of depression. However, long weekly work hours were not associated with anxiety or insomnia, not consistent with earlier research that observed sleep decrements in those working long daily shifts (62). Job strain and effort-reward imbalance were associated with elevated risk of depression, anxiety, insomnia and fatigue, consistent with other studies that have found associations between job stressors and depression (33, 36-38), anxiety (33-35), sleep disturbances (63, 64), and fatigue (65-67).

Some evidence exists that anxiety (68), depression (69, 70), insufficient sleep (71) and fatigue (72) are risk factors for the development of heart disease. Job stressors (and perhaps long work plus home hours) may increase the risk of CVD, in part, by influencing negative affect. Many emotions "are responses to power and status differentials embedded within social situations" (73, p. 55). The current study also adds to the evidence that job stressors and long work hours may increase risk of heart disease through psychosomatic pathways, that is, increases in fatigue and sleep disturbances.

Study strengths

The validity of our findings was enhanced by use of the state-of-the-art technique of ABP monitoring, which is more reliable and valid and more highly correlated with target organ damage and CVD than are casual (clinic) BP measurements (28). We also used standard measures of depression, anxiety, fatigue and insomnia with good reliability and validity.

The potential exists for self-reported work exposures to overestimate associations, particularly for psychological job demands or job efforts, inherently more subjective measures than decision latitude or job rewards. However, participants in the current study did not undertake ABP monitoring until after they had completed the psychosocial questionnaire. Did some participants exaggerate their responsibility and authority levels (decision latitude) because of the prevailing popular belief in "executive stress"? If so, then they would have underreported "job strain", and associations between job strain and ABP would have been underestimated. In the New York City WSBPS, there was no association between case-control status (or mean ABP) and personality/ psychological measures that might have influenced reporting (46, 74).

Could the observed association be due to employees with higher BP selecting into jobs with greater job strain, effort-reward imbalance or shiftwork? There is little evidence to support such a hypothesis. In the New York City WSBPS, no association was found between case-control status (or mean ABP) and personality/psychological measures such as anxiety, hostility, anger, or Type A behavior that might influence job selection (46, 74). In fact, in national studies (75), as in the WSBPS (43), the opposite pattern is observed—people tend to select out of high stress/strain jobs over time.

The prevalence of insomnia in the current study (31.6%) was nearly identical to that observed among 5,850 participants in the Sleep Heart Healthy Study (32.7%), a community-based prospective cohort study (51). The prevalence of depression scores ≥16 in the current study (11.3%) was lower than that observed in a pilot study of the CES-DR among parents of teenage children in Baltimore (21%) (48). These data suggest that the current study sample was not exaggerating their symptoms and provide evidence for the validity of their self-reports.

Study limitations

Restrictions to the range of variation in exposure due to study design might have reduced the statistical power available to detect main effects of long work hours, shiftwork, job strain, or effort-reward imbalance. Despite the fact that lower status and stressful health care occupations were represented in the sample, most participants were members of a labor union, and therefore likely have better working conditions than non-union workers, or workers in "sweatshops". Thus, extremes of stressful work or very long work hours were not observed in this sample.

The internal consistency reliability of the job demands scale of the JCQ (one component of job strain) was low in this sample (alpha=0.58). This may have introduced error in the measurement of job strain and therefore biased associations with outcome variables to the null. In international studies, internal consistency reliability ranged from .51-.72 for this scale (39).

Future research and intervention

These findings need to replicated using larger samples, and with samples with a wider range of work hours and job titles. However, this study does add to the literature on the effects of work stressors such as job strain, effort-reward imbalance and shiftwork on BP and on psychological/psychosomatic distress. Intervention research, which evaluates the impact of interventions designed to reduce these workplace risk factors, needs to be conducted. A good model is a participatory action research (PAR) study conducted by Bourbonnais et al. at an acute care hospital in Québec, Canada that included assessment of job strain, psychological distress and used both qualitative and quantitative methods (76). A 12-month follow up evaluation of the intervention program had positive results. There was a reduction in a number of adverse psychosocial factors, and study participants reported improvements in sleeping problems and "work-related burnout" (77). Such interventions (and their evaluation) are an important component of a public health strategy to address the health effects of workplace stressors, which include worksite surveillance, the development of the field of occupational cardiology, the integration of health promotion with occupational health approaches, and job redesign (78).

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APPENDIX A

RESPONSES TO OPEN-ENDED QUESTIONS

Of the 239 total participants, listed below in parentheses is the number of participants providing an answer in each category; examples of responses provided are listed within each category.

"What is the best part of your job?"

A. Satisfaction in Being a Caregiver/Helping Patients, Clients, Students (n=105)
   i. "Caring for patients."
   ii. "I love to work and care for the children."
   iii. "Helping people with their needs."
   iv. "I love to help people."
   v. "Being confident in knowing that I have helped a human being."
   vi. "Helping people feel better, putting a smile on a sick person's face, educating people about their illness/treatment, learning about medicine."
   vii. "The students."

B. Satisfaction Working with Colleagues (n=45)
   i. "The people I work with."
   ii. "I work together with my co-workers and we respect each other. There is team work."
   iii. "Support from my colleagues."
   iv. "The staff is great and we get along well."
   v. "The opportunity to work with may different departments; learn new things; very pleasant co-workers."
   vi. "Being part of a team."

C. Fulfillment of Career Interests or Goals (n=37)
   i. "Completing my job at the end of the day with satisfaction."
   ii. "The aspect of continuing education and learning new information daily."
   iii. "Doing a good job."
   iv. "Self-satisfaction in accomplishing goals I set for myself."
   v. "Learning and teaching new instrumentation and responsibilities."
   vi. "Being paid to think and not just function."
   vii. "The opportunity to learn new things."

D. Autonomy/Flexibility on the Job (n=21)
   i. "Do my own work."
   ii. "I can make decisions independently."
   iii. "Self-direction."
   iv. "Independence."
   v. "Responsibilities and freedom to decide how to do my work.".

E. Being Employed/Benefits (n=11)

i. "Job security."
ii. "Getting paid."
iii. "Collecting a paycheck every week."
iv. "Healthcare."
v. "The union benefits."

F. Work hours/Location (n=10)
i. "It's not far from home."
ii. "The best part of my job is my hours."

G. Leaving Work (n=8)
i. "Quitting time."
ii. "End of the day."
iii. "Going home."

H. Happy at Work (n=5)
i. "I enjoy work."
ii. "Working environment."

"What is the most difficult aspect of your job?"

A. Overwhelming Demands (being understaffed) (n=57)

I "Dealing with management and constant unfair work demands due to our department being understaffed."

i. "Too much work for one person."
ii. "Cannot complete workload on time, cannot attend to all the phone calls in a timely manner."
iii. "The pressure to get work done, the rushing, the contradictions, the inconsistencies."
iv. "Being understaffed."
v. "Level of stress endured in one day. Balancing constant time pressure and work load."
vi. "Overwhelming number of patients to take care of in a given shift."

B. Difficulty with Colleagues/Lack of teamwork (n=37)
i. "No teamwork."
ii. "Working with my co-workers."
iii. "Trying to get along with other workers."

C. Difficulty with patients/family members/customers (n=29)
i. "Dealing with patient [sic] attitudes and emotions."
ii. "Having to see people suffer."
iii. "Losing patients due to serious health problems."

D. Lack of organization on the job (n=22)

i. "Working in a disorganized and disrespectful environment."
ii. "There is a lack of communication within the department; management does not [sic] inform you what's next or what's going on."
iii. "To overcome persistence of incompetent management on all levels, to see Mount Sinai wasting money."

E. Problems with Lifting (n=16)
i. "Lifting patients."

F. Problems with a supervisor (n=13)
i. "Dealing with unfriendly/moody supervisors. Being treated unequally by supervisor."
ii. "My boss is often difficult and unyielding on certain issues; i.e. working hours, time off."

G. Inadequate working condition (n=11)
i. "It's not very sanitary."
ii. "Standing long hours in different areas of lab work."

H. Frustration with job tasks (n=10)
i. "Poor documentation via the charts."
ii. "Keeping track of miniscule details."

I. Inadequate or Unfamiliar Equipment (n=7)
i. "My inability to provide equipment/supplies because of Mount Sinai's financial issues."

J. Tasks too repetitive (n=6)
i. "The monotony of my task."
ii. "Repetitive nature of tasks, in particular paperwork."
iii. "I'm so used to the job that none of it is difficult. Just doing the same things over and over gets annoying."

K. Lack of recognition and respect (n=4)
i. "Maintaining my own sense of value since I don't believe I'm valued by Mt. Sinai."
ii. "Not being recognized or appreciated for your efforts."

L. Work hours/Location (n=4)
i. "Long hours—sometimes it can be a long day."

M. Poor Pay (n=4)
i. "The salary is below standard for the work we do."

N. Other (n=2)
i. "Not being able to get my point across."
ii. "Lack of communication."

"What are some actions that could be taken to improve working conditions at your current job?"

A. Physical Condition of Work Environment/Condition of Equipment (n=50)
   i. "Better and more updated equipment."
   ii. "More up to date technical tools (computer software) and necessary books."
   iii. "Cleaner environment."
   iv. "Adequate ventilation."

B. Increased Staff (n=48)
   i. "More staff."
   ii. "Hire more workers."

C. Teamwork/Work Organization (n=44)
   i. "We need more teamwork."
   ii. "Fair job responsibilities."
   iii. "Have more freedom and autonomy."
   iv. "Training classes [for promotion]."
   v. "More creative tasks…More interaction with other departments."

D. More Respect from Supervisors/Better Supervision (n=29)
   i. "Treat employees with respect and dignity."
   ii. "More appreciation from administration"
   iii. "Improve supervisor relationship with staff."
   iv. "Upper management should listen to feedback from technical people."
   v. "Less favoritism and equal treatment."

E. Communication (n=13)
   i. "Better communication."
   ii. "Communication, respect for one another."
   iii. Communication between staff and management."

F. Other (n=11)
   i. Not Sure/No Comment
   ii. "I don't know, because it's just not one thing; it's many."

G. Increased Pay (n=8)
   i. "Higher pay."
   ii. "Higher wages."

H. Patient/Consumer Relations with Staff (n=8)
   i. "Family members should participate in care instead of complaining."
   ii. "Getting family members more involved."

I. No Action Needed (n=5)