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Work conditions and masked (hidden) hypertension—insights into the global epidemic of hypertension

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Hypertension is the leading cause of cardiovascular disease. There is considerable evidence that work conditions play an important role in the etiology of essential hypertension. Ambulatory blood pressure during waking hours (work and home) is more strongly associated with subsequent cardiovascular disease than the traditional measurement of casual clinical blood pressure. A person with normal clinical blood pressure but elevated awake ambulatory blood pressure is said to have "masked" (or "occult" or "hidden") hypertension. Masked hypertension is associated with increased cardiovascular risk, and has been observed in 10–30% of adults with normal clinical blood pressure. It has been hypothesized that exposure to workplace stressors first elevates work, but not clinical, blood pressure; after chronic exposure to stressors, both daytime and clinical pressure become elevated. In this manuscript, an algorithm is provided that targets ambulatory monitoring for high-risk groups and helps detect work-related hypertension. A public health approach incorporating clinical guidelines, workplace surveillance, and improved work conditions is recommended for tackling the epidemic of hypertension.

Key terms ambulatory blood pressure; epidemiology; hidden hypertension; job strain; masked hypertension; occult hypertension; review; white-coat hypertension; work stress.

Hypertension is the leading cause of cardiovascular disease (CVD) worldwide (1), and CVD will become the most common cause of death worldwide by 2020 (2). Beginning at 115/75 (systolic/diastolic) mm Hg, the risk of CVD doubles for each increment of 20/10 mm Hg (3).

The worldwide prevalence of hypertension in 2000 was estimated to be 972 million persons or 26.4% of the world's adult population (4). In developing countries, there has been a rapid increase in its prevalence, while, in developed countries, the recent trend towards a decrease in the prevalence of hypertension is reversing (5). Nearly two-thirds of the United States (US) population 60 years of age has persistently elevated blood pressure (>140/90 mm Hg) (6), and those with normal blood pressure at the age of 55 years who survive to age 80–85 years have a 90% risk of developing hypertension (7).

CVD and hypertension appear to be epidemics of relatively recent historical origin (8, 9). Hypertension

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is primarily a disease of industrial societies, with a very low prevalence in nonmarket agricultural communities (9). The rising prevalence of hypertension in developed countries parallels the transformation of worklife during the past century, away from agricultural work and relatively autonomous craft-based work towards machine-based (including computer-based) labor, characteristic of assembly-lines and mass production (10). The development of hypertension as a global epidemic has occurred in conjunction with urbanization and industrialization and, more recently, economic globalization (2). Lower occupational status, a component of socioeconomic status, is a risk factor for hypertension (11). Key characteristics of the assembly-line approach to job design, whether implemented in blue-collar or white-collar settings, are high workload demands combined with low employee control or autonomy (known as "job strain") (12), and, during periods of economic growth, long workhours. Job strain (13–15) and long workhours (16–19) have been identified as important risk factors for hypertension. The emerging body of scientific evidence on workplace risk factors for hypertension also implicates work that combines high effort and low rewards (effort–reward imbalance) (20, 21) and work characterized by "threat–avoidant vigilance". Threat–avoidant vigilance involves maintaining a continuously high level of vigilance in order to avoid disasters, such as loss of human life (14), and it is a feature of several occupations at high risk for hypertension and CVD, including professional drivers (22, 23), air traffic controllers (24), and sea pilots (25). This evidence points to the transformation of work conditions characteristic of industrialization and urbanization as playing a major role in the promotion of the global epidemic of hypertension (10).

The location and techniques of blood pressure measurement provide important information regarding the work-relatedness of hypertension. Blood pressure is higher at work than at home (on a workday) and lower yet on a nonworkday (26). Blood pressure measured during daily life, including work, has shown stronger associations with future CVD than blood pressure measured in a physician's office, and it has shown strong associations with work stressors. This paper reviews this body of research and discusses implications for clinical work, surveillance, and work stressor reduction.

Location and methods of measuring blood pressure

Measuring casual clinical blood pressure

The traditional method for measuring blood pressure, the use of a sphygmomanometer with a stethoscope by a physician or other health professional, is convenient and inexpensive, involves low technology, and offers some predictive validity (27). Notwithstanding its wide use, casual clinical blood pressure is unreliable (27). Blood pressure values recorded by different trained personnel vary by as much as 5–10 mm Hg (28) and have relatively poor test-retest reliability (29). Problems with observer measurement due to digit preference (0 or 5) and varying levels of auditory acuity are well recognized. Casual clinical blood pressure measurements, "which are of enormous value on a population basis, often provide a poor estimate of risk in an individual patient for reasons such as observer error, the 'white-coat' effect (the transient but variable elevation of blood pressure in a medical setting), and the inherent variability of blood pressure [p 2368]" (30).

Ambulatory blood pressure measurement

Advances in technology over the past 40 years permit blood pressure to be measured repeatedly while people go about their normal daily activities over the course of 24 hours using ambulatory (portable) monitors. An individual reading with an ambulatory monitor is somewhat less accurate than one taken by a human observer using the traditional auscultatory technique (31). However, monitoring ambulatory blood pressure provides a large number of readings that can be averaged to provide a more-reliable measure of blood pressure than casual clinical blood pressure, as well as an estimate that reflects a person's blood pressure during normal activities (as opposed to sitting in a doctor's office). Observer bias is also absent because the measurements are taken automatically. Thus ambulatory blood pressure monitoring provides a more-valid measure of a person's "true" blood pressure, which is defined as the mean level over prolonged periods (30). Monitoring ambulatory blood pressure captures the dynamic blood pressure fluctuations in relation to daily life [ie, to changes in posture and physical activity, to location (eg, work versus home), waking versus sleep, and to mood and psychological state]. Blood pressure varies substantially over the course of 24 hours, and its sensitivity to physical and psychosocial stimuli is clearly evident. For example, the mean ambulatory systolic blood pressure is higher by approximately 4 mm Hg during work than during nonwork (32–35) and the mean 24-hour ambulatory blood pressure is lower on nonwork days than on workdays (26, 36).

A disadvantage of ambulatory blood pressure is that the circumstances of recording are uncontrolled, and any given day may be atypical, for various reasons. Nonetheless, ambulatory blood pressure is a better predictor of target organ damage, such as increases in the size of the

heart's left ventricle, than casual clinical blood pressure is (37–40); it is also a better indicator of future incident CVD (41–46).

Measurement of blood pressure—evidence for the etiology of essential hypertension

Casual clinical blood pressure has been used for research into the etiology of essential hypertension for over 100 years. Age, gender, heredity, obesity, and alcohol intake have been identified as risk factors, and a number of physiological mechanisms, such as salt sensitivity, low as well as high renin, and low calcium play a role. These factors, however, taken together, explain only a part of the risk. Despite enormous research efforts, the definition of essential hypertension, which accounts for about 90–95% of all cases of arterial hypertension (47), remains: "patients with arterial hypertension and no definable cause [p 1381]" (47). One reason why the etiology of essential hypertension remains unclear is that casual clinical blood pressure does not reflect the dynamics of daily life, and it is during the latter that a wealth of information can be gleaned about how essential hypertension develops. Monitoring ambulatory blood pressure offers the opportunity to explore a wide range of hypotheses concerning the etiology of essential hypertension, including work and nonwork stressors. Among work-related stressors, the most intensively investigated has been job strain.

Job Strain. Studies of job strain and casual clinical blood pressure have not consistently shown significant associations (14, 48). However, in 2000, a review of 11 cross-sectional studies of job strain (or its components) and ambulatory blood pressure among men found that the majority reported significant positive associations with work ambulatory blood pressure (14). In the five studies in which blood pressure was also measured outside work, job strain was also associated with increased nonwork systolic ambulatory blood pressure. Of the six cross-sectional studies of job strain and ambulatory blood pressure among women, four reported significant positive associations with work systolic ambulatory blood pressure (15). Work systolic ambulatory blood pressure among workers facing job strain is typically 4–8 mm Hg higher than among those without job strain. Differences between casual clinical blood pressure and ambulatory blood pressure findings may be explained, in part, by the imprecision and biases of taking casual clinical blood pressure measurements and that ambulatory blood pressure, but not casual clinical blood pressure, includes large numbers of readings taken at work. Several ambulatory blood pressure studies with null or mixed findings were single-occupation studies with limited variance in job characteristics that used conventional generic instruments to assess the components of job strain, namely, high demands and low decision latitude (49–52). The only long-term prospective study of this association between job strain and ambulatory blood pressure found that men exposed to chronic job strain (measured at two points in time separated by 3 years) exhibited an 11–12 mm Hg higher systolic and 6–9 mm Hg higher diastolic work ambulatory blood pressure than men unexposed at both times. In addition, men reporting job strain at baseline but no job strain in the 3-year follow-up exhibited a significant decrease in systolic ambulatory blood pressure of 5.3 mm Hg at work and 4.7 mm Hg at home (13). The cross-sectional association between job strain and elevated ambulatory blood pressure is strong and fairly consistent, with important corroborative longitudinal data, indications of a dose–response relationship (53) and biological plausibility (54). Thus there is substantial evidence supporting the hypothesis that exposure to job strain is causally related to the development of essential hypertension.

Other work stressors. Associations with blood pressure elevation have also been observed for long workhours (16–19), effort–reward imbalance (20, 21), and "threat–avoidant vigilance" (14, 22, 23). Mixed evidence exists for shift work (55). Some empirical evidence implicates chronic exposure to noise (56). For other physical factors, such as cold, heavy lifting, and glare, physiological data show acute blood pressure increases with exposure, but there is no epidemiologic evidence available. Chemicals that may be pressor agents include lead and arsenic (56). In addition, lower occupational status is a risk factor for hypertension (11). More research is needed on the relative contribution of these factors alone and in combination to the etiology of essential hypertension. For example, work stressors have been found to be associated in some studies with overweight and alcohol use (57, 58), and thus health behavior related to these may, in part, mediate the association between work stressors and hypertension.

There is also evidence that work stressors both mediate the association between lower socioeconomic position and CVD risk (59) and interact with socioeconomic position. For example, the cross-sectional association between job strain and blood pressure was substantially greater for men with lower status jobs in the New York City worksite blood pressure study (60), and for both men and women in the Framingham heart study [unpublished data: Landsbergis P, Schnall P, Chace R, Sullivan L, D'Agostino R. Psychosocial job stressors and cardiovascular disease in the Framingham Offspring Study: a prospective analysis [poster]. In: 4th ICOH Conference on Work Environment and Cardiovascular Disease; 2005. Newport Beach (CA): 2005].

Masked (hidden) hypertension

The monitoring of ambulatory blood pressure is beginning to be recognized as having an important role in the diagnosis of hypertension. On one hand, it can be used to rule out "white coat" hypertension (the "false positive" diagnosis). On the other hand, monitoring ambulatory blood pressure allows for the identification of masked (also known as "occult") hypertension [ie, elevated daytime or 24-hour blood pressure, but normal casual clinical blood pressure ("false negative" diagnosis)]. [Other names used to describe this phenomenon reflect uncertainty or confusion over its etiology: "white-coat normotension", "reversed white-coat effect", "isolated ambulatory hypertension".] Unfortunately, people with normal casual clinical blood pressure are rarely followed up to have their blood pressure re-checked.

Masked hypertension is a much more serious condition than "white-coat" hypertension. People with masked hypertension have levels of target organ damage, such as increased left ventricular mass (40, 61, 62) and carotid plaque (61–63), similar to persons diagnosed with hypertension ("true positives", people with elevated ambulatory blood pressure and casual clinical blood pressure) and significantly higher than people with normal blood pressure. People with masked hypertension also have a significantly increased risk of developing CVD relative to people with normal blood pressure (64–66) or [with one exception (66)] people exhibiting white-coat hypertension.

Apparently controlled hypertension

Increased target organ damage (67) and an increased risk of CVD (41, 42) have also been observed among persons with diagnosed hypertension whose blood pressure is being treated and appears to be controlled in clinical settings (casual clinical blood pressure <140/90 mm Hg), but whose daytime ambulatory blood pressure is elevated when compared with that of treated persons with normal casual clinical blood pressure and normal ambulatory blood pressure (67). Persons treated for diagnosed hypertension whose blood pressure appears to be controlled have also been labeled "masked hypertensives"; however, such a label is somewhat misleading since they have already been identified as having hypertension. On the other hand, a high proportion (16–55%) of patients with hypertension who appear to be responding well to treatment (ie, casual clinical blood pressure <140/90) have elevated ambulatory blood pressure (inadequately controlled hypertension) (68). Therefore, monitoring ambulatory blood pressure on a workday is recommended for patients with hypertension, especially those with exposure to workplace stressors.

Prevalence

In general population studies, the prevalence of masked hypertension among people with normal casual clinical blood pressure typically ranges from 10% to 30% (table 1). The variety of definitions of masked hypertension makes prevalence comparisons problematic. The European Society of Hypertension Working Group and the American Heart Association have both recommended that a mean daytime systolic ambulatory blood pressure of 135 mm Hg or a diastolic ambulatory blood pressure of 85 mm Hg (and a casual clinical blood pressure of <140/90 mm Hg) be considered the appropriate ambulatory blood pressure threshold (69, 70).

Risk factors

To help determine the etiology of masked hypertension, some general population studies have identified its risk factors, including age, gender, smoking, alcohol use, coffee consumption, and physical activity (table 1). Masked hypertension was more common among men than women in six studies (40, 61, 62, 65, 66, 71, 72). Masked hypertension was more common among older participants in four studies (61, 62, 65, 66, 71), but was not associated with age in two studies (40, 72). In addition, two studies that used the definition of "ambulatory blood pressure greater than the casual clinical blood pressure" (73, 74) concluded that masked hypertension was associated with younger age. This inconsistency may have resulted, in part, from the inclusion of unemployed persons (eg, retirees, students) in some studies. If employment or work stress is a risk factor for masked hypertension, then the association between age and masked hypertension may be confounded by the length of employment or chronic exposure to work stress. Therefore, future studies should specify whether participants are employed, or they should provide analyses of employed subgroups to help clarify the association between age and masked hypertension.

Only two published studies of masked hypertension have examined work-related risk factors. Gallo et al (75) found that masked hypertension, based on systolic blood pressure, was more common among blue-collar and clerical workers than among higher status white-collar workers. However, such a pattern was not observed for diastolic blood pressure (75). In the longitudinal worksite blood pressure study (60), which measured job strain and ambulatory blood pressure at multiple points in time separated by an average of 3 years, job strain was slightly more common among men with masked hypertension at baseline, using a cutpoint of 85 mm Hg for diastolic blood pressure (table 1), although this association was not statistically significant. In an unpublished analysis of

Table 1. Prevalence of and risk factors for masked (hidden) hypertension determined in general population empirical studies published in English in 1988–2006. (95% CI = 95% confidence interval, ABP = ambulatory blood pressure, DBP = diastolic blood pressure, HTN = hypertension, NS = not significant, SBP = systolic blood pressure, Tx = treatment, WCH = white-coat hypertension, CVD = cardiovascular disease)

Reference	Clinical blood pressure		Ambulatory blood pressure			Study sample			Masked (hidden) hypertension	
	SBP	DBP	SBP	DBP	Duration	Female (%)	Location	Source, age	Prevalence [a]	Risk factors (versus people with normal clinical blood pressure)
Fiedler et al, 1988 (88)	..	≤90	..	>85	Daytime, workday	26	New Jersey, USA	Worksite; 23–74 years; 36.2 years (mean)	9.7% (11/113)	..
Imai et al, 1996 (82)	<140	<90	Borderline: 134–143; definite: ≥144	Borderline: 79–84; definite: ≥85	24 hours, weekday	69	Ohasama, Japan	Population; 20–79 years; 59 ±12 years; 30% HTN Tx	10.4% borderline; 3.2% definite (untreated sample)	..
Rasmussen et al, 1998 (73)	..	..	..	..	Daytime, workday	48	Glostrup, Denmark	Population; 41–72 years; Tx HTN excluded	..	Systolic ambulatory blood pressure > clinical blood pressure: 41–42 years: 72% women, 86% men; 71–72 years: 38% women, 51% men
Selenta et al, 2000 (71)	<140	..	≥135	..	12 hours, workday	52	Vancouver, Canada	111 community, 208 students; 17–68 years; Tx HTN excluded	23%	Male, older age, smoking, alcohol use
	..	<90	..	≥85	..	..	..		24%	
	<140	<90	≥135	≥85	..	..	..		33.8% [b] (104/308)	
	<140	<90	≥140	≥90	..	..	..		16.2% [b] (50/308)	
Belkic et al, 2001(80)	..	<85	..	≥85	Work	0	New York City, USA	Worksites: normotensives + mild HTN (no Tx for 3 weeks); 30–60 years	19.9% (36/181)	Job strain: prevalence ratio =1.55; unadjusted odds ratio=1.76 (95% CI 0.70–4.40) [b]
Liu et al, 1999 (61)	<140	<90	≥134	≥90	Daytime, workday	54	New York City, USA	324, worksites; 35 patients; 30–66 years	Men: 31.6% (50/158); women: 8.0% (11/137)	Male, older age, body mass index; smoking (NS)
Sega et al, 2001 (40)	<140	..	≥125	..	24 hours, workday	42	Milan, Italy (PAMELA)	Population; 25–74 years; Tx HTN excluded	Men: 18.8% (116/617); women: 4.4% (27/616)	Male, older age
	..	<90	..	≥79	..	..	..		Men: 13.8% (97/701); women: 8.0% (43/535)	..
Tsai, 2003 (72)	Daytime systolic ABP minus clinical blood pressure ≥5				Daytime, weekday	59	Taipei, Taiwan	Volunteers, 38–45 years (mean); no HTN Tx	48.3% (14/29) (excluding WCH)	Male, lower body mass index; age (NS)
Björklund et al, 2003 (64)	<140	<90	≥135	≥85	Daytime	0	Uppsala, Sweden	Population; 70 years; CVD; Tx HTN excluded	30.4% (82/270)	..
Gallo et al, 2004 (75)	<140	..	≥140	..	48 hours, workdays	100	Kent (OH) USA	Community; employed; 41 (SD 9) years, CVD; Tx HTN excl.	27.2% (28/103)	Blue-collar: 39%, clerical: 28%, white-collar: 21%
	..	<90	..	≥90	..	..	..		7.8% (8/103)	Blue-collar: 6%, clerical: 11%, white-collar: 5%
Ohkubo et al, 2005 (65)	<140	<90	≥135	≥85	Daytime, workdays	60	Ohasama, Japan	Population; ≥40 years, 61 years (mean); 30% HTN Tx	Men: 26.5% (80/302); women: 21.4% (141/658)	Older age, HTN Tx (P<0.05); male (P<0.10), smoking (NS)
Bombelli et al, 2005 (74)	Daytime ABP minus clinical blood pressure >0				Daytime, workday	49	Milan, Italy (PAMELA)	Population; 25–74 years	Men: 39.0% (SBP), 33.6% (DBP); women: 40.1% (SBP), 34.7% (DBP)	Younger age (65.6% if 25–34 years, 10.5% if 65–74 years), gender (NS)
Mancia et al, 2006 (66)	<140	<90	≥125	≥79	24 hours, workday	49	Milan, Italy (PAMELA)	Population; 25–74 years	Men: 22.7% (126/556); women: 7.5% (46/617)	Male, older age, smoking, body mass index, cholesterol, glucose

[a] Numerator = number of participants with an ambulatory blood pressure above the threshold; denominator = number of participants with casual clinical blood pressure below the threshold.

[b] Reanalysis of original data by Landsbergis.

male participants, using the criteria of <140/90 mm Hg for casual clinical blood pressure and 135/85 mm Hg for awake ambulatory blood pressure for masked hypertension and compared with those with a casual clinical blood pressure of <140/90 mm Hg and an awake ambulatory blood pressure of 135/85 mm Hg,

odds ratios for job strain were 1.54 [95% confidence interval (95% CI) 0.61–3.91] for the baseline and 5.74 (95% CI 1.86–17.72) at the 3-year follow-up, adjusted for age, race, body mass index, education, current smoking, alcohol use, and worksite.

In unpublished findings from a New York City sample (primarily female), comparing health care workers with masked hypertension to those with normal casual clinical blood pressure and ambulatory blood pressure as already defined, odds ratios in the range of 1.5–5.0 were observed for job strain, effort–reward imbalance, evening, night or rotating shiftwork, and having only a secondary education.

Masked workplace hypertension

If masked hypertension occurs because the "at work" component of daytime ambulatory blood pressure is elevated, then it can be considered "masked workplace hypertension". Since most published studies do not partition the work and home components of daytime ambulatory blood pressure, it is unknown whether the "at work" component is primarily responsible for the high prevalence of masked hypertension, or the increased risk of target organ damage and CVD due to masked hypertension. One study did find a higher correlation between left ventricular mass and work ambulatory blood pressure than home ambulatory blood pressure or clinical blood pressure (76). In addition, because ambulatory blood pressure is generally higher at work than at home (32–34) and work stressors appear to be causally related to the elevation of work ambulatory blood pressure, it is plausible to hypothesize that work stressors are important risk factors for masked hypertension and its sequelae. Therefore, data from the studies in table 1 need to be re-analyzed, and future studies need to examine the role of masked "workplace" hypertension as a cause of target-organ damage and CVD.

Suggested stages in the development of hypertension

On the basis of the presumed mechanisms of neurogenic hypertension (77), we previously hypothesized (56, 78) that there are three stages in the etiology of essential hypertension.

Stage 1. When a person is first exposed to workplace stressors, ambulatory blood pressure (primarily systolic) is elevated at work and casual clinical blood pressure remains normal (a masked hypertension effect). The elevation of blood pressure during waking hours may lead to "early markers" of CVD (increases in left ventricular mass and atherosclerosis), indicating that the person has more severe hypertension. Evidence of these structural changes would classify the person at stage 2, despite normal casual clinical blood pressure.

Stage 2. With chronic exposure to stressors, casual clinical blood pressure also becomes elevated. Psychosocial factors are likely correlated with both workplace blood pressure and casual clinical blood pressure, and structural changes in the heart and vasculature continue.

Stage 3. Self-sustaining structural processes in the vascular system may lead to a disjuncture between exposures to workplace stressors and blood pressure, since (i) the hypertension process has become autonomous or (ii) exposure to workplace factors that elevate blood pressure may have ceased due to retirement or selection into a less stressful job.

Targeting the monitoring of ambulatory blood pressure towards high-risk groups

The monitoring of ambulatory blood pressure is relatively expensive and skilled-labor intensive. In the United States alone, if monitoring ambulatory blood pressure were to become a routine procedure for the diagnosis and monitoring of hypertension, annual costs could reach USD 6 billion (37). Therefore, guidance is needed for clinicians and worksite cardiovascular screening programs to identify the persons and groups with normal casual clinical blood pressure who would be the most likely to benefit from the monitoring of ambulatory blood pressure. Persons with CVD, a high CVD risk profile, diabetes, or target organ damage would be one indicator. Casual clinical blood pressure above 130/80 mm Hg or risk factors for ambulatory blood pressure elevation, such as smoking, alcohol use, heavy coffee consumption, and lack of physical activity, could be considered. Given the strong associations between work stressors and ambulatory blood pressure, we have presented an algorithm (79, 80) to aid in this goal. Further research is needed to determine the magnitude of associations between job strain, other job stressors, nonwork risk factors, and masked hypertension, which could help refine our recommendations, given in table 2.

Lower cost alternatives to the monitoring of ambulatory blood pressure

Given the high costs of monitoring ambulatory blood pressure, further research is needed on less expensive

Table 2. Preliminary algorithm to identify high-risk persons and groups most likely to benefit from ambulatory blood pressure (ABP) monitoring and clinical and workplace interventions. (CVD = cardiovascular disease, LVMI = left-ventricular mass index)

Clinical blood pressure	Exposure to workplace stressors [a]							
	No	Yes: ABP monitoring (awake ABP ≥135/85 mm Hg) [b]						
		No	Yes (masked hypertension)			Yes		
			Recommendation	Increased LVMI, carotid atherosclerosis		Recommendation	Increased LVMI, carotid atherosclerosis	
				No	Yes		No	Yes
<140/90; >115/75	Follow routinely	Follow routinely	Reduce exposure to specific stressors; electrocardiography/ carotid echo (evaluate early CVD markers) and follow-up	Stage 1 hypertension	Stage 2 hypertension	·	·	·
≥140/90	Repeat clinical blood pressure (to rule out "white coat" hypertension)	White-coat hypertension	·	·	·	Reduce exposure to specific stressors; electrocardiography/ carotid echo (evaluate early CVD markers), clinical evaluation and follow-up	Stage 2 hypertension	Stage 3 hypertension

[a] Direct epidemiologic and physiological evidence for job strain, effort–reward imbalance, long workhours, noise, lead, arsenic; mixed evidence for shift work. High-risk occupations: urban transit operators, truck drivers, air traffic controllers, sea pilots. Physiological and indirect epidemiologic evidence for threat–avoidant vigilant work. Only physiological evidence for cold, heavy lifting, glare exposure (56).

[b] ABP to assess severity and pattern of elevated blood pressure, to (i) aid in clinical decision making (eg, optimize medication regimen) and (ii) suggest feasible strategies to minimize exposure to work pressors (eg, adjustment of work schedule).

methods, such as "home" or self-monitoring, which would help identify people with elevated blood pressure outside the doctor's office. Home monitoring of blood pressure, using upper-arm digital monitors, has been recommended for persons diagnosed with hypertension, although only some of the many home blood pressure monitors on the market have satisfied the recommended validation criteria (70). One study found a similar percentage of participants with masked hypertension detected by ambulatory blood pressure (14%) and home blood pressure (11%) (81). Home blood pressure predicts CVD risk better than casual clinical blood pressure for treated patients with hypertension (40, 42, 82).

Wrist blood pressure monitors, which also store readings digitally but are somewhat easier to use than upper-arm cuffs, have also become popular. However, blood pressure can vary substantially in different parts of the arterial tree, and wrist monitors can also be inaccurate if not held at heart level (70). A newer device with a position sensor that keeps the monitor near the level of the heart while recording has also met the validation criteria (83). Another potential limitation is the immediate feedback provided by the devices, which may influence activity or cause anxiety.

A key benefit of monitoring is that measurements can be taken during work and at home with a minimum interruption of ongoing activity. Another advantage of self-monitoring is that home or work blood pressure readings can be collected by self-monitoring over an extended period of time (70), whereas it is not practical to have multiple clinic visits or multiple days of ambulatory blood pressure measurements. One disadvantage of self-monitoring is the inability to assess the lack of blood pressure "dipping" during sleep, a suggested CVD risk factor (30).

Concluding remarks

Masked hypertension is a serious individual health problem and a public health concern, for which there has been little research into the role of workplace risk factors. One study found that lower occupational status (blue-collar jobs) is a risk factor, while another found some evidence of a role for job strain. More research is needed to examine the relationships between work organization and masked hypertension.

In addition, the role played by work conditions in the development of hypertension and CVD needs to be brought into the realm of clinical practice. Guidelines are needed for the assessment and management of patients exposed to environmental workplace risk factors (84). Given the availability of inexpensive upper-arm and wrist blood pressure monitors, it should be feasible for all working people to have a sufficient number of blood pressure measurements at work to assess masked workplace hypertension. Working people found to have masked hypertension and exposure to workplace psychosocial stressors could be referred for further assessment of target-organ damage (eg, carotid atherosclerosis and left ventricular mass index). In addition, given the

high proportion of patients whose hypertension appears to be controlled (casual clinical blood pressure <140/90 mm Hg), but who have elevated ambulatory blood pressure, we recommend the monitoring of ambulatory blood pressure on a workday for patients with hypertension, especially those with exposure to workplace stressors.

Unfortunately, given the high prevalence of hypertension and emerging insights concerning work-related hypertension, the individual clinician could become overwhelmed if he or she *alone* attempts to follow the given recommendations. In addition to a role for the clinician, a public health approach is needed, in which blood pressure and workplace risk factors for blood pressure elevation are systematically evaluated on a large scale by appropriately trained allied health workers (eg, industrial hygienists or occupational health nurses). In the Tokyo Declaration (85), occupational health experts from the United States, Europe, and Japan called for a program of "surveillance at individual workplaces and monitoring at national and regional levels in order to identify the extent of work-related stress health problems and to provide baselines against which to evaluate efforts at amelioration [p 5]." Occupations with high prevalence levels of hypertension could be targeted for further evaluation. The clinician can also play an active public health role in this process by identifying clusters of work-related hypertension as potential "occupational sentinel health events" (86).

Surveys in developed countries show increases in stressful work conditions during the period 1990–2005 (87). While comparable temporal trend data are not yet available from developing countries, rapid industrialization suggests that the prevalence of work stressors is increasing in developing countries as well. These trends may well be contributing to the rapid increase in hypertension prevalence in developing countries and the reversal of the previous trend of a decrease in hypertension prevalence in developed countries (5). Reducing work stressors and the prevalence of hypertension will require the worksite surveillance and public health approach described in this paper. In addition, it will require policy efforts at the local, national, and international levels to improve work conditions and promote heart healthy workplaces (85).

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