

Prospective Surveillance of Hypertension in Firefighters

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The authors evaluated blood pressure and antihypertensive medication use in 334 firefighters in an occupational medical surveillance program. Firefighters received written summaries of their examination results, including blood pressures, and were encouraged to see their personal physicians for any abnormal results. The mean age of the participants was 39 years, and the vast majority were men (n=330). The prevalence of hypertension was 20% at baseline (1996), 23% in 1998, and 23% in 2000. Among firefighters with high blood pressure readings, only 17%, 25%, and 22% were taking antihypertensive medications at the baseline, 1998, and 2000 examinations, respectively. Medical surveillance was effective in detecting hypertension in firefighters; however, after 4 years of follow-up, only 42% of hypertensives were receiving treatment with medications, including only 22% of firefighters with hypertensive readings. Overall, 74% of hypertensives were not adequately controlled. Possible reasons for low treatment rates may be the inadequate recogni-

tion among primary care physicians that mild hypertension is a significant risk factor for cardiovascular disease. (J Clin Hypertens. 2003;5:315–321)

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Among US firefighters, coronary heart disease has been the major cause of on-duty deaths from 1977–1998, accounting for 45% of fatalities.^{1,2} Hypertension is a major risk factor for cardiovascular disease (CAD).³ Screening for hypertension among the general population is considered one of the most important preventive measures to reduce CAD morbidity and mortality.^{4,5} Current public health challenges, according to the sixth report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-VI), include improved hypertension awareness, increased recognition of high-normal blood pressure (BP) as a factor in the development of hypertension and target organ damage, and improved control of hypertension.³

Primary and secondary prevention for CAD risk factors, in general, and BP, in particular, has been promoted in the context of workplace wellness programs,⁶ surveillance examinations,^{7,8} and fitness for duty evaluations.^{9–12} Because uncontrolled hypertension poses health risks and may jeopardize public safety through sudden incapacitation, BP control is a major criterion in medically determining “fitness for duty” in firefighters, commercial drivers, pilots, and other professions.^{13–20} Fitness for duty may be succinctly defined as the ability to safely perform one’s essential job functions. The National Fire Protection Association (NFPA) specifies systolic blood pressure (SBP) <180 mm Hg, diastolic blood pressure (DBP) <100 mm Hg, and no target organ damage as acceptable for fitness for duty.^{21,22}

Occupational medical examinations for firefighters

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focus on determining fitness for duty and surveillance for potential health effects due to exposure to fires, smoke, and hazardous materials. While these examinations may also detect personal health problems, occupational physicians usually refer firefighters back to their personal physicians for further evaluation and medical treatment. However, little is known about the effects of occupational examinations in firefighters on the assessment and control of BP over time.^{23,24}

The objectives of this article are to describe the population distribution of BP and other coronary artery risk factors in Massachusetts Hazardous Materials Firefighters in Massachusetts according to the updated JNC-VI guidelines and to evaluate longitudinal changes in their BPs.

METHODS

Study Population

The study population consisted of municipal firefighters who joined regional hazardous materials teams on a contractual basis in Massachusetts, in addition to their primary occupational duties as municipal firefighters in local fire departments.⁹ The 340 study participants underwent a baseline medical examination in 1996 or 1997 when a statewide medical surveillance program was initiated. The surveillance was mandated under a federal Occupational Safety and Health Administration standard for hazardous waste workers. The examinations were designed to detect possible adverse health effects from hazardous materials duty and to determine fitness for duty for the hazardous materials teams. The firefighters consented in writing to physical examinations and the results were confidential. The Institutional Review Boards of the Harvard School of Public Health, the Olympus Specialty and Rehabilitation Hospital (now, Northeast Specialty Hospital), and the Cambridge Hospital all approved review of the medical records for research purposes.

Hazardous materials firefighters are selected based on the successful completion of appropriate training; no fitness or other physical criteria are applied. In terms of CAD risk factor profiles, our cohort²⁵ is comparable to other nonhazardous materials cohorts of firefighters from other parts of the country.^{23,26}

Six firefighters were excluded from the study population, leaving a final sample of 334 firefighters. Two firefighters were excluded because they had a medical examination but never joined a hazardous materials team, three were excluded because of inadequate follow-up information, and one was excluded because he was already on "injured on duty" status at his baseline examination. Twenty firefighters did not have a follow-up examination in 1998, and 20 more did not have a follow-up examination in 2000 for various reasons including injuries on duty, premature retirement, or resignation.

Blood Pressure Measurements

Medical surveillance examinations were performed during working hours at three contracted Massachusetts hospitals for the dual purposes of medical surveillance and fitness for duty evaluation based on a written protocol.⁹ Resting BP readings were recorded according to routine clinical practices at each hospital, in millimeters of mercury, as part of the vital signs evaluation and documented at every examination. Before entry into the computerized repository, BP readings were rounded up to the nearest even digit. Single readings of BP obtained at each examination and documented on each firefighter's summary sheet were used for the purpose of this analysis. JNC VI was used to classify firefighters into different BP categories at each examination.³ Hypertension was defined as a BP $\geq 140/90$ mm Hg or any use of antihypertensive medication.

There were no significant differences in the mean SBP of firefighters from the three hospitals at the baseline examination (121, 123, and 124 mm Hg, $p=0.24$). A significant difference for diastolic blood pressure was observed (76, 80, and 81 mm Hg, $p<0.0001$); however, the proportion of firefighters with hypertension did not differ between the three hospitals ($p=0.20$). The firefighters were notified in writing of the results of their evaluation, including laboratory findings at every examination, and were encouraged by the examining physicians to contact their primary care physicians for any abnormal results.

Additional Risk Factors

Prospective information on several other factors was also collected routinely at every examination and entered into the computerized repository. These factors included age, sex, height, weight, smoking history, physical examination findings, and use of medications. A number of clinical tests, including a routine electrocardiogram, spirometry, and visual and acoustic acuity tests, were also performed. Finally, a broad range of laboratory tests was administered at each annual examination. These tests included complete blood count and biochemical measurements (e.g., blood glucose, lipid profile, liver enzymes, serum creatinine, urinalysis).

STATISTICAL ANALYSES

Statistical analyses were performed using SAS software (version 6.12, SAS Inc., Cary, NC)²⁷; t test and χ -square tests were used to compare possible differences in standard CAD risk factors between firefighters with and without hypertension at baseline. Additional comparisons were also made between the blood pressure levels of firefighters at baseline with the corresponding levels at the follow-up examinations (ANOVA). A p value <0.05 was considered statistically significant, and all tests were two-sided.

Table I. Distribution of Cardiovascular Disease Risk Factors by Hypertension Status in Hazardous Materials Firefighters at the Baseline Examination (1996–1997)

		HYPERTENSION STATUS*				
RISK FACTOR	N	NORMOTENSIVE (n=266)		HYPERTENSIVE (n=68)		P VALUE
		%	(N)	%	(N)	
Age ≥45 years	334	19.6	(52)	47.1	(32)	<0.0001
Smoking	333	9.1	(24)	11.8	(8)	0.50
Body mass index ≥30 kg/m²	330	31.3	(82)	48.5	(33)	0.008
Total cholesterol ≥240 mg/dL	321	32.2	(82)	42.4	(28)	0.12
Triglyceride level ≥200 mg/dL	203	28.3	(47)	37.8	(14)	0.26
Blood glucose ≥126 mg/dL	146	2.6	(3)	10.3	(3)	0.06
Creatinine ≥1.2 mg/dL	333	37.4	(99)	30.9	(21)	0.32
*Hypertension status defined as systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or any use of antihypertensive medications						

RESULTS

The mean age of the study participants at baseline was 39 years (range 20–58 years), and almost all of them were men (n=330). The mean SBP and DBP for the whole cohort at the baseline examination was 123 mm Hg and 79 mm Hg, respectively. The mean BP in firefighters with normal BP as compared with those with hypertension at the baseline examination were 119/77 mm Hg and 138/88 mm Hg, respectively. Among firefighters with high BP, the mean BP was lower in those who were not taking medications at baseline (139/89 mm Hg) as compared with those who were taking anti-hypertensive medications (145/92 mm Hg). A similar trend was observed when we compared hypertensive firefighters not taking medications in the 2000 follow-up examination (139/89 mm Hg) with those on antihypertensive medications (143/92 mm Hg).

The distribution of CAD risk factors by hypertension status among firefighters at baseline is shown in Table I. Firefighters with hypertension were significantly older and were more likely to have higher body mass indices. There was a trend toward higher casual blood glucose levels in hypertensive firefighters. Firefighters with hypertension were also more likely to be smokers, to have higher cholesterol, higher triglycerides, and take lipid-lowering medications, although these differences were not statistically significant.

The prevalence of high BP readings and hypertension in the total cohort of firefighters was: 18% and 20% at baseline (1996), 20% and 23% in 1998, and 17% and 23% in 2000, respectively. In the Figure we present the proportion of firefighters with hypertension (either high BP or antihypertensive medication use) by different age categories. This was higher for older firefighters as expected. The slightly higher proportion of hypertensive firefighters in the total cohort in follow-up

examinations is most likely due to the aging of the study cohort. The two older age categories of firefighters had a lower prevalence of hypertension at the last follow-up examination (2000) compared with the previous surveillance examinations, likely due to a higher drop-out of firefighters with medical problems among older hypertensives compared with normotensives.

In Table II we compare the distribution of firefighters' BP readings in the different categories at baseline and follow-up examinations. At each periodic examination, about one in every five firefighters was found to be hypertensive by BP readings, with the majority of these firefighters categorized as having stage 1 hypertension. Thirty-seven percent of firefighters with hypertensive readings at the baseline examination had high SBP, 34% had high DBP, and 29% had both high SBP and DBP readings. In the

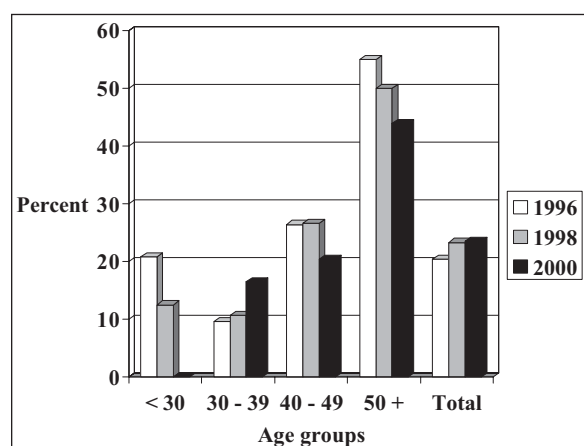


Figure. Hypertension by age group in the study population at baseline and follow-up examinations; white bars represent population distribution in 1996; gray bars represent 1998; dark bars represent the distribution in 2000

Table II. Comparison of the Distribution of Blood Pressure Readings, Hypertension, and Antihypertensive Use in Firefighters Over Time

	1996–1997 EXAMINATION	1998 EXAMINATION	2000 EXAMINATION
Number of firefighters screened	334	314	294
Blood Pressure (mm Hg)			
Mean Systolic ($\pm$ SD)	122.7 ($\pm$ 13.3)	122.1 ($\pm$ 13.1)	122.8 ($\pm$ 12.8)
Mean Diastolic ($\pm$ SD)	79.1 ($\pm$ 9.3)	77.1 ($\pm$ 10.3)	79.1 ($\pm$ 8.6)
Blood pressure categories*	% (n)	% (n)	% (n)
Normal (<130/85 mm Hg)	58.7 (196)	63.1 (198)	62.9 (185)
High-normal (130/85 $\leq$ BP<140/90 mm Hg)	23.6 (79)	16.9 (53)	19.7 (58)
Stage 1 hypertension (140/90 $\leq$ BP<160/100 mm Hg)	15.0 (50)	15.2 (48)	15.7 (46)
Stage 2 hypertension (160/100 $\leq$ BP<180/110 mm Hg)	2.4 (8)	4.5 (14)	1.7 (5)
Stage 3 hypertension (BP $\geq$ 180/110 mm Hg)	0.3 (1)	0.3 (1)	0
	% (n/N)	% (n/N)	% (n/N)
Firefighters with hypertensive readings* (total)	17.7 (59/334)	20.0 (63/314)	17.4 (51/294)
Hypertensive readings on antihypertensive medications	16.9 (10/59)	25.4 (16/63)	21.6 (11/51)
Firefighters with hypertension [†]	20.4 (68/334)	23.3 (73/314)	23.5 (69/294)
Hypertensives [†] on antihypertensive medications	27.9 (19/68)	35.6 (26/73)	42 (29/69)
Adequate blood pressure control among those on medications	47.4 (9/19)	38.5 (10/26)	62.1 (18/29)
Adequate blood pressure control among all hypertensives [†]	13.2 (9/68)	13.7 (10/73)	26.1 (18/69)
*According to the sixth report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure; [†] hypertension defined as systolic blood pressure $\geq$ 140 mm Hg, diastolic blood pressure $\geq$ 90 mm Hg, or any use of antihypertensive medications; BP=blood pressure			

last follow-up examination (2000), 29% had high SBP, 45% had high DBP, and 26% had both.

Despite yearly examinations and written recommendations for follow-up, only 17%–25% of firefighters with high BP readings and 28%–42% of those with hypertension (defined by blood pressure or medication use) were taking antihypertensives at the baseline, 1998, and 2000 examinations. Among firefighters taking antihypertensive medications at baseline (n=19), 47% had adequate BP control (<140/90 mm Hg) (n=9). Of the remaining 10 firefighters, 50% (n=5) had both high SBP and high DBP. At the last follow-up examination (2000), among 29 firefighters on antihypertensive medications, 62% were found to have adequate BP control (n=18), and of the remaining 11 firefighters, 36% (n=4) had both high SBP and high DBP. The proportion of firefighters on medications with adequate BP control at baseline (47%) compared with the 2000

examination (62%) was not significantly increased ($p=0.31$) most likely due to small numbers. At the end of the study period, only 26% of hypertensive firefighters demonstrated adequate control.

DISCUSSION

In our prospective study of BP among firefighters, we found that about one in five firefighters had high BP readings at every examination and about an additional 20% had high normal BP readings. Despite yearly examinations and encouragement to follow-up with their personal physicians, almost 80% of firefighters with hypertensive BP readings ($\geq$ 140/90 mm Hg) were not receiving treatment. In addition, despite annual follow-up examinations, only 26% of hypertensive firefighters ($\geq$ 140/90 mm Hg or antihypertensive medication use) demonstrated adequate BP control (<140/90 mm Hg) after 4 years.

These findings are important because several lines

of evidence suggest that uncontrolled hypertension puts firefighters at greater risk for adverse outcomes. We previously reported in a prospective evaluation that stage 2 hypertension among firefighters (BP $\geq 160/100$ mm Hg) was associated with increased risks for adverse employment status outcomes such as early retirement, resignation, and injured-on-duty status.²⁸ Second, hypertension is a major risk factor for CAD,³ and coronary heart disease was responsible for 45% of on-duty fatalities in firefighters from 1977–1998.^{1,2} In a case-control study of on-duty coronary heart disease deaths among firefighters, we found that hypertension was an independent predictor associated with a four- to five-fold increased risk of on-duty death.²⁹ Autopsy results showed that many of the deceased firefighters had left ventricular hypertrophy suggesting uncontrolled hypertension for significant time periods. Another finding from this study worth noting was the observed CAD risk factor clustering among individuals with high BP. We previously reported a high prevalence of dyslipidemia and obesity and clustering with hypertension in the same cohort.²⁵ This finding has been demonstrated in nonoccupational cohorts also.^{30,31} CAD risk factor clustering is an additional reason for even mildly hypertensive patients to receive further evaluation.

Possible reasons for low treatment rates we observed and the relatively low rates of adequately controlled BP may include the mild degree of BP elevation observed in most of firefighters with high BP readings. In our study, occupational physicians, offered only surveillance and counseling to firefighters. Although firefighters were given verbal and written recommendations to follow up with their primary care physicians, it was beyond the scope of occupational physicians' duties to prescribe specific treatment and provide follow-up care. In addition, the firefighters' primary care physicians, who were then responsible to initiate drug therapy, may have been less likely to do so, especially because they are usually unfamiliar with firefighters' occupational duties and CAD hazards. Recent findings also show that primary care physicians often have higher BP thresholds for the diagnosis and treatment of hypertension than the JNC-VI guidelines.^{32,33}

The results of these investigations call for renewed efforts among occupational and primary care physicians for improved detection, treatment, and control of hypertension among firefighters. National Fire Protection Association, which recommends medical standards for firefighters, may need to consider stricter and more specific BP guidelines to improve the current figures. Perhaps the current recommended fitness for duty guideline "BP less than 180/100

mm Hg and no target organ damage"²¹ should be modified to a lower BP threshold (e.g., BP $<160/100$ mm Hg) and should also require ongoing follow up of hypertensive firefighters until they achieve adequate control ($<140/90$ mm Hg). Direct incentives toward achieving the above BP goal could also be explored. Furthermore, an integration of worksite health promotion and medical care would be ideal for firefighters to ensure adequate and cost-effective follow-up after screening examinations.^{34–37}

The findings of our study on the prevalence of hypertension fall within the range of other reports for the general population. Overall 24% of the US adult population had hypertension according to the Third National Health and Nutrition Examination Survey; similar findings were reported for Canada.^{38,39} A recent update from the National High Blood Pressure Education Program showed parallel findings.⁴⁰ In addition, our findings are in agreement and reinforce the findings of previous studies reporting on the inadequate control of hypertension in the general population.^{41–44}

Several limitations are worth noting in our study. The annual examinations and data collection processes were conducted in three different hospitals for six regional hazardous materials teams. Although we observed a significant difference comparing the mean DBP between the three hospitals at the baseline examination, we did not find a significant difference in the proportion of firefighters with hypertension between the three hospitals. Another limitation relates to the use of single BP readings obtained during periodic examinations. Single BP readings, however, have been previously shown to be a significant predictor of CAD outcomes.⁴⁵ In addition, although individual treatment plans cannot be based on single BP measurements alone, population comparisons could be useful in elucidating temporal trends and evaluating surveillance programs in occupational settings.

In conclusion, in this study we observed a significant number of firefighters with high BP readings at each periodic medical examination. The vast majority of those firefighters were not taking anti-hypertensive medications, and of those few receiving treatment, only 47%–62% demonstrated BP readings lower than 140/90 mm Hg. Certain administrative measures like the introduction of global CAD risk factor screening programs (e.g., hypertension, smoking, diabetes, obesity, dyslipidemia) in fire departments would help improve the current risk factor profile of firefighters and prevent adverse health outcomes. Occupational and primary care physicians should increase their efforts to educate firefighters about the consequences of uncontrolled high BP and the benefits of treatment

and provide evidence-based management for those who require medical treatment.

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