Fitness for Duty Evaluations in Hazardous Materials Firefighters

Stephen N. Kales, MD, MPH
Jon M. Aldrich, BA
Gerry N. Polyhronopoulos, BS
David Artzerounian, MD
Thomas Gassert, MD, MPH
Howard Hu, MD, ScD, MPH
Karl Kelsey, MD, MOH
Charles Sweet, MD, MPH
David C. Christiani, MD, MPH, MS

We analyzed results from the medical examinations of 340 hazardous materials firefighters and applied various objective standards in simulated fitness for duty determinations. Ten percent had elevated blood pressures, 13% had far visual acuity worse than 20/30 in one or both eyes, and 38% had abnormal audiometry. The strictest standards for resting blood pressure and corrected visual acuity would have failed 2% and 1% of the cohort, respectively. For audiometry, 0%–5% of the cohort would have failed, depending on the hearing requirements set. The strictest hearing standard did not allow for corrective devices so that few failures would be reversible. Visual and audiometric testing and measurement of resting blood pressure all have significant clinical yields. Studies of simulated firefighting are needed to establish minimum hearing requirements and determine whether corrective devices can be worn safely during duty.

From The Cambridge Hospital, Cambridge, Mass. (Dr Kales, Mr Aldrich, Mr Polyhronopoulos); Channing Laboratory, Brigham and Womens Hospital (Dr Hu, Dr Kelsey), Harvard Medical School (Dr Kales, Dr Hu, Dr Kelsey, Dr Christiani), and the Department of Environmental Health, Occupational Health Program, Harvard School of Public Health (Dr Kales, Dr Gassert, Dr Hu, Dr Kelsey, Dr Christiani), Boston, Mass.; The Work Connection at Holyoke Hospital, Holyoke, Mass. (Dr Artzerounian); the Department of Family and Community Medicine, UMASS Medical Center, Worcester, Mass. (Dr Artzerounian, Dr Sweet); the Center for Occupational and Environmental Medicine, Massachusetts Respiratory Hospital (Dr Gassert, Dr Hu, Dr Kelsey, Dr Christiani), Braintree, Mass.; UMASS Health System, Marlborough Hospital, Marlborough, Mass. (Dr Sweet); and the Pulmonary/Critical Care Unit, Massachusetts General Hospital/Harvard Medical School, Boston, Mass. (Dr Christiani).

Address correspondence to: Stephen N. Kales, MD, MPH, Occupational Medicine, Department of Medicine, The Cambridge Hospital, 1493 Cambridge Street, Cambridge, MA 02139.

1076-2752/98/4010-0925$3.00/0

There are an estimated 1 million persons in the United States involved in firefighting, a hazardous occupation with potential exposures to a wide variety of chemical, physical, and biologic hazards. [1] In addition, an increasing number of communities have developed hazardous materials (HAZMAT) teams composed of specially trained firefighters to respond to chemical spills, fires, and accidents. HAZMAT firefighters are potentially exposed to high levels of numerous toxic chemicals that may be generated during fires, explosions, and spills. HAZMAT fire fighters also have a greater likelihood of mixed chemical exposures. [1,2]

Clinically and toxicologically, these exposures may be hard to document. For example, routine medical surveillance applied in a pre-scheduled fashion has not been able to discriminate between more- and less-exposed hazardous waste workers.[3] Even post-incident, substance-specific testing may not be able to document certain accident-related exposures.[4]

The Occupational Safety and Health Administration standard for hazardous waste workers recommends medical surveillance for workers exposed to these potential hazards. The 1992 National Fire Protection Association (NFPA) standard medical requirements for firefighters (1582)[5] recommend medical examinations for all firefighters. Medical examination of firefighters has a number of potential benefits, such as detection of adverse health effects earlier; provision of baseline exami-

nations that may be useful in the diagnosis and management of subsequent overexposures; and determination of fitness for duty (ie, detection of medical problems that may compromise personal, coworker, and/or public safety). In addition, analysis of surveillance data for entire cohorts may identify or confirm occupational hazards. [6]

Limited information is available at present, however, on the adverse health effects of HAZMAT duty on firefighters' health and the usefulness of various examination components in determining fitness for duty.[7] While our preliminary study suggested significant exposure to noise and pulmonary irritants, most testing is currently applied on theoretical grounds. For example, we initially included blood lead and protoporphyrin determinations in our surveillance examinations, based on the demonstration of lead in exposure assessments of actual fires and other possible exposures during HAZMAT duty. Although some of our firefighters' blood leads were above the national average, longitudinal study documented significant declines in both blood lead levels and zinc protoporphyrin levels, suggesting decreasing exposures and the adequacy of current protective equipment.[7] Therefore, we were able to eliminate such testing from our program on an evidence-based rationale. The clinical utility and cost-effectiveness of the remaining surveillance examination components are unknown.

In this study, we studied various physical and laboratory examination results from a large cohort of HAZMAT firefighters. We analyzed the role of these results in actual fitness for duty determinations by attending physicians and then applied various objective criteria, including guidelines from the proposed NFPA revision of standard 1582[8] to our population as determinants of fitness for duty. This allowed us to compare our physicians' clinical determinations against the objective criteria. Finally, we examined the practical implications of applying various uniform objective criteria to our cohort.

Methods

Subjects

The subjects were all members (n = 340) of six regional hazardous materials teams of the Commonwealth of Massachusetts. They included 268 (79%) HAZMAT technicians and 72 (21%) support members. The population included 4 women (1%). The team members' ages ranged from 21 to 58, with a mean of 39 and a standard deviation of 6.9. They are all members of municipal fire departments in addition to their HAZMAT duty with the state teams. Some had undergone previous surveillance examinations, while for some individuals, these were baseline examinations after they had joined the teams.

Baseline and Periodic Medical Examinations

These examinations were performed for the dual purposes of medical surveillance of HAZMAT firefighting and to determine fitness for the state HAZMAT teams. These fitness determinations for state duty do not apply to firefighters' work status/capacity with their municipal (non-HAZMAT) fire departments.

Medical surveillance examinations for all subjects were performed at three hospitals—Massachusetts Respiratory, Marlborough, or Holyoke Hospital—in 1996 or 1997 in the first year of a statewide surveillance program. All examinations were conducted in a similar fashion. The components of the examinations were in accordance with both the Occupational Safety and Health Administration standard on hazardous waste workers and the 1992 NFPA 1582 medical requirements for firefighters.[5] Determinations of fitness were left up to the judgment of the attending physicians. No predetermined fitness criteria were applied. The attending physicians were all board-certified in occupational medicine, and all except one were also board-certified in internal medicine.

Examinations included a detailed medical, smoking, and environmental/occupational history tailored to emergency responders; physical examination; visual and audiometric testing; routine laboratory tests (complete blood count, blood urea nitrogen, creatinine, alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, and urinalysis); and spirometry. All individuals also underwent a mini–fitness evaluation in 1996/1997. This test required a firefighter to ascend and descend two flights of stairs while wearing a respirator, with pre- and post-test assessments of vital signs. Electrocardiogram, posterior-anterior chest roentgenogram, and red blood cell cholinesterase activity were also done as baselines if the 1996/1997 examination was the individual's baseline examination or the test had not been done previously.

Summary results of each firefighter's examination, including the attending physician's determination of fitness for duty, were transferred to the Massachusetts Respiratory Hospital, where they were entered into a statewide computerized medical records repository.

Fitness for Duty Criteria

Various methods and criteria for determining fitness for duty were compared. These included the following: (1) the fitness for duty determinations by the examining attending occupational medicine physician; (2) selected guidelines from the proposed revision of NFPA 1582[8]; (3) criteria agreed upon by the investigators and examining physicians at a medical "workshop" meeting*; and (4) additional criteria selected for the present study. Table 1 shows the various cutoff values for resting blood pressure, post-mini–fitness

* The workshop took place in January 1997. Actual examination results were discussed, and the proposed NFPA criteria were reviewed.

TABLE 1
Objective Criteria for Exclusion From Fitness for Duty*

Source	Resting Blood Pressure	Mini-Fitness Evaluation	Visual Acuity	Audiometry	Pulmonary Function
Proposed Revision NFPA 1582	SBP >179 or DBP >99	NA	Corrected binocular vision worse than 20/30	Hearing deficit in **unaided** worst ear: >25 dB in 3 of the 4 frequencies: 500, 1000, 2000, 3000 Hz or; >30 dB in either 500, 1000, or 2000 Hz **AND** average >30 dB for: 500, 1000, 2000, 3000 Hz	No cutoff given
Medical workshop	DBP >109	Post-exertion SBP >219 or DBP >109	Corrected binocular vision worse than 20/40	Same as NFPA, but for best **aided** ear	No cutoff given
Additional criteria selected for present study	DBP >104			Average hearing deficit in best **aided** ear >40 dB for: 500, 1000, 2000 Hz[9]	%Pred FVC <70 %Pred FVC <65 %Pred FVC <60 %Pred FEV_1 <70 %Pred FEV_1 <65 %Pred FEV_1 <60

* NFPA 1582, National Fire Protection Association standard 1582; SBP, systolic blood pressure; DBP, diastolic blood pressure; %Pred, percent predicted; FVC, forced vital capacity; FEV_1, 1-second forced expiratory volume.

blood pressure, visual and audiometric deficits, and spirometry based on NFPA, workshop consensus, and other study criteria for determining that a firefighter is unfit for duty.

Determination of the Severity of Visual and Acoustic Deficits

All firefighters with far visual acuity worse than 20/30 in one or both eyes were selected for further review. Binocular acuities were obtained from their hospital charts and compared with the study criteria.

Attending physicians reviewed all audiograms and rated them as "normal," "borderline," or "abnormal," based on their own clinical interpretations. These ratings were included in each firefighter's summary results. These clinical ratings were based on the entire spectrum of hearing measured (500, 1000, 2000, 3000, 4000, 6000, and often up to 8000 Hz). The actual audiograms for all firefighters judged "abnormal" were then obtained. Each audiogram was systematically reviewed and compared to study criteria for minimum hearing requirements (Table 1). Those who were judged "normal" or "borderline" were assumed to have passed all study criteria.

Comparisons of Attending Physician Determinations of Fitness for Duty vs NFPA and Workshop Criteria

For the purposes of these analyses, one firefighter with an orthopedic injury who was unfit per his attending physician was included as being unfit by NFPA and workshop criteria. Even though orthopedic injuries were not selected as study criteria, such an injury would have made a firefighter at least temporarily unfit by both NFPA and workshop standards.

Results

Fitness for Duty as Determined by the Attending Physician

A total of 331 (97%) firefighters were determined to be fit for duty, and nine (3%), all males, were judged unfit. These nine were all examined at a single hospital and deemed unfit for a variety of reasons. All nine were examined and disqualified before the medical workshop. None of the firefighters examined at the other two hospitals were deemed unfit.

High resting or post-mini–fitness evaluation blood pressure values were cited as contributing to lack of fitness for duty in seven of the nine unfit firefighters. Only one of these seven, however, failed either the NFPA or medical workshop criteria (Table 1) for resting blood pressure with a resting diastolic blood pressure of 106. Three of the seven failed medical workshop criteria for post-mini–fitness evaluation blood pressure, including the subject mentioned above with a high resting diastolic blood pressure.

Other reasons for being determined unfit were abnormal liver function tests (transaminases) in two cases, an orthopedic injury in one case, and poor vision in one case. In the vision case, acuity did not fail either the NFPA or medical workshop criteria. In one additional case, no explicit reason was present in the

TABLE 2
Study Criteria Performance of Subjects Judged Unfit by Attending Physicians*

Subject	Resting Blood Pressure	Mini-Fitness Evaluation	Visual Acuity	Audiometry	Pulmonary Function	Attending Physician Rationale(s)
1	OK*	OK	OK	OK	OK	Post-exercise blood pressure, LFTs
2	OK	DBP >109	OK	OK	OK	Resting and post-exercise blood pressure
3	OK	OK	OK	OK	OK	Resting blood pressure
4	OK	OK	OK	OK	OK	Post-exercise blood pressure, LFTs
5	DBP >104	DBP >109	OK	Failed NFPA and Workshop	OK	Resting blood pressure, abnormal laboratory results
6	OK	SBP >219 and DBP >109	OK	OK	OK	Post-exercise blood pressure, restricted from hot environments
7	OK	OK	OK	OK	OK	Not in database
8	OK	OK	OK	OK	OK	Poor vision, resting blood pressure
9	OK	OK	OK	OK	OK	Knee injury

* OK, passed all study criteria; LFTs, abnormal liver function tests.

database, but this subject had microscopic hematuria.

Multiple reasons for being unfit were cited in four of the nine cases: high blood pressure with abnormal liver function in two cases (one of these two also had an abnormal chest film), high blood pressure and poor acoustic acuity in one case, and high blood pressure and poor visual acuity in one case.

Three of the nine firefighters who were determined to be unfit by the attending physician were also unfit by any of the criteria listed in Table 1. In addition, the firefighter with the orthopedic injury would have been judged temporarily unfit by both NFPA and workshop criteria, for a total of four. The profiles of these nine "unfit" firefighters for all of the different study criteria for fitness for duty are summarized in Table 2.

Resting Blood Pressure

A total of 36 of 340 (10%) firefighters had a high resting blood pressure measurements (systolic >140 or diastolic >90). For those firefighters with elevated blood pressure values, the mean systolic was 144 ± 12 and the mean diastolic 92 ± 8. No firefighter was found to have a systolic blood pressure exceeding 179 (proposed revision of NFPA 1582).

Seven had diastolic values exceeding 99 (proposed revision of NFPA 1582); of these seven, three exceeded 104 and one exceeded 109 diastolic (medical workshop). Of these seven firefighters, only one (whose diastolic was between 104 and 109) was unfit, as determined by the attending physician.

Mini–Fitness Evaluation/Post-Mini–Fitness Blood Pressure

A total of seven of 336 firefighters (2%) failed the medical workshop criteria for post-fitness blood pressure, and three were judged unfit by the attending physician. Five firefighters had systolic values greater than 219, and three had diastolic values exceeding 119. One subject's systolic and diastolic pressures were both greater than the criteria.

Visual Acuity

A total of 44 of 335 (13%) firefighters had vision worse than 20/30 in one or both eyes and were selected for further review. Five of 335 (1%) firefighters in the cohort failed the NFPA criteria for corrected binocular far visual acuity. One (0.3%) of these firefighters also failed the medical workshop criteria. None of these firefighters were judged unfit by their attending physicians.

Audiometry

Audiometry was rated as "abnormal" for 125 of 331 firefighters (38%). No information was available for nine (3%). The audiogram for one of the abnormals was unavailable for interpretation. Of the firefighters with abnormal hearing, 121 of 124 (98%) had hearing losses exceeding 20 dB at one or more of the frequencies tested (500, 1000, 2000, 3000, 4000, 6000, or 8000 Hz) in one or both ears. One hundred twelve of 124 (90%) had hearing losses exceeding 30 dB at one or more frequencies in one or both ears. Eighty-five of 124 (68%) had hearing losses exceeding 40 dB at one or more frequencies in one or both ears. Fifty-two of 124 (42%) had hearing losses exceeding 50 dB at one or more frequencies in one or both ears. Twenty-four of 124 (19%) had hearing losses exceeding 60 dB at one or more frequencies in one or both ears. Most had various degrees (≥20 dB) of hearing loss at multiple frequencies in one or both ears.

Sixteen of 330 firefighters (5%) failed the NFPA criteria for hearing acuity, including eight (2%) who also failed the medical workshop standard. Only one firefighter (0.3%) who failed both of these criteria was judged unfit by the attending physician. None of the firefighters failed the most liberal audiometric criterion chosen, which comes from the Department of Transportation standard.[9]

Pulmonary Function

A total of 19 of 334 firefighters (6%) had either a percent-predicted forced vital capacity (FVC) value or

TABLE 3
Performance Failures of Total Cohort on Study Criteria

Source	Resting Blood Pressure	Mini–Fitness Evaluation	Visual Acuity	Audiometry	Pulmonary Function	Total
Proposed revision NFPA 1582	7/340 (2.0%)	NA	5/335 (1%)	16/330 (5%)	NA	28
Medical workshop	1/340 (0.3%)	7 /336 (2%)	1/335 (0.3%)	8/330 (2%)	NA	17
Additional criteria selected for present study	3/340 (0.9%)	NA	NA	0/330 (0%)	%FVC <70: 1/334 (0.3%) %FVC <65: 1/334 (0.3%) %FVC <60: 0 %FEV_1 <70: 3/334 (1%) %FEV_1 <65: 0 %FEV_1 <60: 0	7
Total failures	7	7	5	16	4	33*

* Grand total is less than sums of subtotals because of individuals who failed on more than one criteria.

1-second forced expiratory value (FEV_1) of less than 80%. For these individuals, the mean percent-predicted FVC was 80, with a standard deviation of 6. Their mean percent-predicted FEV_1 was 77, with a standard deviation of 6. Only four failed any of the pulmonary function criteria selected for the present study. None of these four subjects was judged unfit for duty. No subjects were found to have a percent-predicted FVC of less than 60%. One firefighter's percent-predicted FVC was less than 65%. Three other firefighters had a percent-predicted FEV_1 of less than 70%. No subjects had a percent-predicted FEV_1 of less than 65%.

Table 3 summarizes the performance failures of the entire cohort on all of the study criteria.

Comparisons of Attending Physician Determinations of Fitness for Duty vs NFPA and Workshop Criteria

Two-by-two tables that compare attending physicians' fitness determinations with simulated NFPA and medical workshop determinations are shown in Table 4.

Among individuals determined unfit by any NFPA criteria, only two were unfit per the attending physicians' determinations (2 of 28; 7%). Among individuals determined fit by all NFPA criteria, 98% were fit per the attending physicians' determinations (293 of 300; 98%).

TABLE 4
Attending Physician Determinations vs Selected Study Criteria

Criteria	Attending Physician Determination: Unfit	Fit
All NFPA criteria		
Unfit	2	7
Fit	26	293
NFPA audiometry		
Unfit	1	8
Fit	15	307
All workshop criteria		
Unfit	4	4
Fit	13	304
Workshop audiometry		
Unfit	1	8
Fit	7	315

Among individuals determined unfit by any workshop criteria, four were unfit per the attending physicians' determinations (4 of 17; 24%). Of the nine firefighters who were failed by an attending physician, one had not completed the mini–fitness evaluation. Four of the remaining eight failed one or more medical workshop criteria (4 of 8; 50%). Among individuals fit by all medical workshop criteria, 99% were fit per the attending physicians' determinations (304 of 308; 99%).

Among individuals determined unfit by NFPA or medical workshop hearing standards, only one was determined to be unfit by an attending physician (1 of 16; 6%; and 1 of 8; 12%; respectively).

Discussion

Attending physicians failed only a minority of those individuals who would have failed any of the NFPA or medical workshop criteria. This lack of agreement has several likely contributing explanations. When the examining physicians reviewed the exclusion criteria from the proposed revision of NFPA 1582, they tended to feel that the criteria were too strict and not supported by hard evidence. In the case of the medical workshop criteria, most of the initial examinations had been done prior to the workshop. Without mandatory, objective cutoff criteria already in place, it seems likely that physicians were reluctant to judge as unfit those individuals who were actively working as firefighters without reported difficulties. Further support of this explanation is the fact that three individuals who failed medical workshop criteria were examined after the workshop and were still determined to be "fit" even though the attending physicians had agreed as a group that such abnormalities should render a firefighter unfit.

The lack of objective criteria that were agreed upon beforehand and uniformly applied resulted in dis-

qualification of some individuals from duty, even though others had equally poor or worse test results. For example, two firefighters with resting diastolic blood pressure values of 106 and 110, respectively, were determined to be "fit", while one individual with a resting diastolic blood pressure value of 106 and several others with lower diastolic values were found to be "unfit" at least in part on the basis of high blood pressure. Therefore, the uniform application of objective criteria appears to be important in terms of fairness and consistency. In addition, such a system ensures that those firefighters with the most severe abnormalities are at least temporarily disqualified until the abnormalities are corrected.

This study did not consider that the attending physician may be integrating other information from the medical history and examination, such as comorbidities, health behaviors, and risk factors for chronic illness, to make gestalt impressions of the worker's health status. (This will be investigated in a companion study.) Even if excellent numerical guidelines for determining fitness existed, it would seem important to allow the integration of clinical acumen and impressions. The potential likelihood of arbitrary decisions indefinitely disqualifying individual firefighters should be decreased by allowing for the treatment of correctable problems and by offering an appeals process with a second opinion by a specialist or occupational physician.

Individual Examination Components

Assessment of resting blood pressure had a significant yield, 10%, for finding blood pressure elevations (>140/90). How many of these represent hypertension, transient elevations, or "white coat" elevations is unknown. The risk of incapacitation during duty because of sustained high blood pressure is unknown. Even the strictest guideline (NFPA), however, would have disqualified very few firefighters (2%). True persistent elevations in blood pressure of this magnitude (≥80/100) can be confirmed by repeated measurements over time and lowered with treatment to acceptable levels. Therefore, the proposed NFPA guideline for resting blood pressure seems quite reasonable. The final approved 1997 NFPA 1582 maintained the same numerical criterion for blood pressure. [10]

Seven firefighters would have failed the medical workshop guideline for post-mini–fitness evaluation blood pressure. The risk associated with having an exaggerated blood pressure response to this test is unknown. Attempts to standardize the performance of this test among the various hospitals also created a number of practical and theoretical difficulties. The validity of such a test in determining whether a firefighter is physically capable of carrying out HAZMAT duty is also unknown. Because of all of these considerations, this evaluation was eliminated from subsequent examinations by the consensus of the examining physicians and the investigators.

For visual acuity, like resting blood pressure, a significant number of abnormalities were found. Even the strictest (NFPA) fitness guidelines would have disqualified very few firefighters, while the medical workshop criteria would have failed only one subject on the basis of his vision. In essentially all cases, these deficits should have been easily corrected with appropriate refraction. In the absence of data showing that a corrected far binocular vision of 20/40 is inadequate, the workshop criteria might be stringent enough for cases that for some reason cannot be corrected to 20/20 or 20/30.

The high prevalence of abnormal audiometry (38%) in this study is consistent with firefighters' known risk for hearing loss.[7,11] Because aging is also associated with hearing loss and results are usually judged relative to "normal" hearing (0 dB), some of those rated as "abnormal" may have hearing no worse than expected for their age. Nonetheless, given the sheer quantity of abnormalities and their severity in many cases, audiometry clearly has a high clinical yield in this population. The results also highlight the need for comprehensive hearing conservation programs for firefighters that include both hearing protective devices and engineering controls to reduce noise exposures.[11–13]

In addition, 5% of our cohort had hearing impairments severe enough to disqualify them by the proposed NFPA standard. Preliminary analysis of follow-up examinations suggest that more firefighters would fail this standard every year as cumulative hearing losses produce greater deficits. Because the proposed NFPA standard did not allow for correction by hearing aids, and few of the failures are likely to be reversible, the application of this standard could have had serious implications for manpower and could have produced legal challenges to its implementation.

The final 1997 NFPA 1582[10] changed hearing requirements from Category A to Category B conditions.[†] It also specified that to be disqualified, a firefighter "in addition to the above (failing the minimum numerical hearing requirements), is unable to pass a job-specific functional hearing task OR a Hearing In Noise Test." [10] Although the final 1582 standard is more liberal than the proposed one, direct studies of job safety and performance as a function of hearing impairment are needed. In addition, studies of simu-

[†] The NFPA defines a Category A Medical Condition as precluding "a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." Category B conditions are conditions that, based on their "severity or degree, could preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others."[10]

lated firefighting and HAZMAT duty could also help determine the degree of hearing deficit that begins to impair job performance and safety. Such investigations should also assess whether or not corrective devices can or cannot be worn safely during active duty. Research should also address the design of appropriate "job-specific functional hearing task."

The workshop audiometric criteria would have disqualified only half as many firefighters as the proposed NFPA standard and also allowed for correction. They would appear to be more practical unless proven to be inadequate in protecting safety. The Department of Transportation criterion[9] would not have disqualified any firefighters. The present investigation, however, cannot support or refute the appropriateness of any of the hearing standards studied. Again, research on job safety and performance as a function of hearing impairment and studies of simulated firefighting are needed to more objectively verify minimum hearing requirements.

Spirometry produced a small but not insignificant number (6%) of abnormalities (either a percent-predicted FVC or FEV_1 less than 80%). Very few firefighters had spirometry values worse than any of the study criteria, and none were worse than 65% of predicted. The usefulness of spirometry in determining fitness for the use of a self-contained breathing apparatus (SCBA) is not clear-cut. Trial respirator use may be helpful.[14] In this study, all of the subjects had already been working as firefighters and wearing SCBAs in the course of their regular municipal firefighting duties. This study suggests that spirometry plays little role in determining fitness for duty. Spirometry may be useful, however, in identifying individuals who are at potential risk for subsequent losses of pulmonary function because of lower baseline function, as well as looking for longitudinal group trends.

Conclusions

Visual and acoustic acuity testing are essential components of fitness for duty determinations that can detect potential safety problems. In the case of vision, the vast majority of deficits will be correctable. In the case of hearing, studies of simulated firefighting are needed to establish minimum hearing requirements and whether corrective devices can be worn safely during duty. The wider implementation of hearing conservation programs is also crucial in preventing further hearing losses. Assessment of resting blood pressure seems prudent to identify persons with possible hypertension and to temporarily disqualify those with pressures persistently $\geq$180/100 until corrected.

The adoption and uniform application of objective criteria will determine fitness for duty in a more consistent manner. Temporary disqualifications from fitness for duty should provide an impetus for the correction of reversible abnormalities in many cases.

Acknowledgments

The authors thank the members of Massachusetts District Hazardous Materials Response Teams; the Massachusetts Hazardous Materials Response Program; Chief Stephen Clendenin, Director of the Commonwealth of Massachusetts Hazardous Materials Response Program; the staffs of Massachusetts Respiratory, Marlborough, and Holyoke Hospitals; and Ms Dianne Plantamura and Ms Karen Encarnacion for their continuing support of this research. The authors also thank Mr Stephen Foley and Dr Richard Gerkin for their helpful comments.

This study was supported by National Institute for Occupational Safety and Health grant 1 K01 OH00156, and National Institutes of Health grants 1K07ES00266, ES00002, and ES05947.

References

1. Morse L, Owen D, Becker CE. Firefighter's health and safety. In: Rom WN, ed. *Environmental and Occupational Medicine*. Boston: Little, Brown; 1992:1197–1204.
2. Gochfeld M. Medical surveillance of hazardous waste workers: principles and problems. *Occup Med.* 1990;5:1–7.
3. Favata EA, Gochfeld M. Medical surveillance of hazardous waste workers: ability of laboratory tests to discriminate exposure. *Am J Ind Med.* 1989;15:255–265.
4. Wolff MS, Schecter A. Use of PCB blood levels to assess potential exposure following an electrical transformer explosion. *J Occup Med.* 1992;34:1079–1083.
5. *NFPA 1582 (1992 Edition): Standard on Medical Requirements for Fire Fighters.* Quincy, MA: National Fire Protection Association; 1992.
6. Weeks JL, Peters JM, Monson RR. Screening for occupational health hazards in the rubber industry: part I. *Am J Ind Med.* 1981;2:125–141.
7. Kales SN, Polyhronopoulos GN, Christiani DC. Medical surveillance of hazardous materials fire fighters: a two-year prospective study. *J Occup Environ Med.* 1997;39:238–247.
8. *NFPA 1582 (Proposed Revision): Standard on Medical Requirements for Fire Fighters.* Quincy, MA: National Fire Protection Association; 1997.
9. Qualifications of Drivers. Code of Federal Regulations, Title 49, Volume 4, Part 391. Revised October 1, 1997:736–756.
10. *NFPA 1582 (1997 Edition): Standard on Medical Requirements for Fire Fighters.* Quincy, MA: National Fire Protection Association; 1997.
11. Tubbs RL. Noise and hearing loss in firefighting. *Occup Med.* 1995;10:843–856.
12. Tubbs RL. Medical surveillance of HAZMAT response firefighters [correspondence]. *J Occup Environ Med.* 1997; 39:1135.
13. Kales SN, Christiani DC. Medical surveillance of HAZMAT response firefighters [correspondence]. *J Occup Environ Med.* 1997;39:1135–1136.
14. Harber P. The evaluation of pulmonary fitness and risk. *Occup Med.* 1988;3:285–298.