Spirometric Surveillance in Hazardous Materials Firefighters: Does Hazardous Materials Duty Affect Lung Function?

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*We analyzed spirometry results for 351 male hazardous materials firefighters from 1996 to 1999 who underwent one or more annual medical surveillance/fitness for duty examinations: 276 (79%) technicians and 75 (21%) support members. Support members had a very limited potential for hazardous materials exposure and served as referents. In cross-sectional comparisons, the technicians' average forced vital capacity and forced expiratory volume in 1 second were either statistically better or not significantly different from that of the support members at all four examinations. Longitudinally, no statistically significant differences were seen for forced vital capacity. The mean percent of predicted forced expiratory volume in 1 second decreased by 3% for technicians (*P = *0.029), support controls (*P = *0.433), and the total cohort (*P = *0.014). Although respiratory irritants are the most common type of exposure in hazardous materials releases, the results suggest that hazardous materials technicians do not lose pulmonary function at a more accelerated rate than support team firefighters.* (J Occup Environ Med. *2001;43:1114–1120*)

The US Agency for Toxic Substances and Disease Registry has suggested that over 400,000 persons in the United States may be involved as first responders to hazardous materials accidents, including emergency medical technicians, firefighters, police, and others.[1] An increasing number of communities and industries have developed hazardous materials (hazmat) teams composed of specially trained individuals to respond to chemical spills, fires, and accidents. Although firefighters respond to fewer fires than in the past,[2] they have become more involved in the mitigation of hazardous materials accidents.[2–5] Respiratory exposure to irritant substances is the most common type of exposure associated with hazardous materials releases.[6–10] Therefore, the potential of hazardous materials duty to affect pulmonary function is an important question in terms of the respiratory health of firefighters and other first responders.

The US Occupational Safety and Health Administration (OSHA) standard on Hazardous Waste Workers (29 CFR 1910.120) requires medical examinations for hazardous waste workers, including members of hazardous materials response teams.[11] An identical US Environmental Protection Agency standard (40 CFR 11) applies to state and municipal employers in states without designated OSHA programs.[1,12] The OSHA standard requires preassignment examinations and periodic examinations at least every 2 years, but

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the content of the examinations is not specified.

Because of the potential for respiratory exposures, most medical surveillance programs include spirometry in their examination protocols.[13] This common practice is in agreement with recommendations that pulmonary function tests be considered as part of the medical examination process for hazardous waste workers[1,14,15] and for firefighters.[5,16,17] Despite the widespread use of spirometry in these medical examinations, limited information is available at present on the utility of monitoring pulmonary function testing among professional hazardous materials handlers. Because it has been estimated that over 1 million persons in the United States are involved in firefighting alone,[18] the utility of tests used to monitor health status among firefighters and other hazardous materials handlers is an important issue in the provision of preventive health services.

In a small, prospective study of 40 hazardous material firefighters, we found few spirometric abnormalities and none that could be specifically linked to exposures or accident response.[19] The current study was undertaken to evaluate further possible health effects of hazardous materials firefighting duty as measured by spirometry in a larger, statewide cohort over 3 years and in our original cohort over 6 years.

Methods

Subjects

The study population included all 351 male members of six regional hazardous materials response teams of the Commonwealth of Massachusetts who underwent one or more annual, state-mandated medical surveillance/fitness for duty examinations between 1996 and 1999. All firefighters were examined on a confidential basis. The Institutional Review Boards of the Harvard School of Public Health and The Cambridge Hospital approved review of the firefighters' medical records for research purposes.

All of the subjects were also members of municipal fire departments in addition to their hazardous materials duty with the state teams. In 1996 to 1997 (year 01 of the primary study), the initial cohort ($n = 336$) included 267 (79%) hazardous materials technicians and 69 (20%) support members. The majority of the technicians were already incumbent members of the hazardous materials teams before the start of the study. After the year 01/1996 to 1997 examination and before the end of the study period, 15 new members joined the teams and 14 firefighters (12 support members and two technicians) changed positions. Including all four examinations, data were collected for 351 firefighters: 276 (79%) technicians and 75 (21%) support members.

Hazardous Materials Duty Exposure Status

Technicians are involved with the actual assessment and mitigation of hazardous materials accidents within the "hot," or contaminated, zone of the accident. Most situations are responded to on a "level A" basis, which entails the use of vapor-tight clothing and a positive pressure self-contained breathing apparatus. Field decontamination is performed routinely after all accidents unless the hazard poses a threat only by pulmonary absorption (eg, carbon monoxide).

During hazardous materials duty, support members do not enter the hot zone of an accident and their role is limited and ancillary. Therefore, they are presumed to have a very low potential for hazardous materials exposure compared with the technicians. Both technicians and support members perform regular fire duty with their local fire departments. Because support members are not exposed in their hazardous materials duties but do serve as municipal firefighters, they are an ideal control group for the investigation of potential health effects arising from duty within the contaminated zone of hazardous materials accidents.

Baseline and Follow-Up Medical Examinations

Medical surveillance examinations for the firefighters were performed at one of three hospitals in 1996 or 1997 in year 01 of a statewide surveillance program. A smaller number ($n = 214$) were examined during the year 02 examinations in 1997. This timing was because of an administrative decision by the Commonwealth of Massachusetts in 1997 to have all teams' subsequent examinations conducted within a 2-month time period in the fall of each year. The year 01 examinations were conducted throughout 1996 and part of 1997. Because 16 months is the maximum time period allowed between examinations, some firefighters were not reexamined until fall 1998.

Forty technicians from team 1, one of the six teams, had baseline examinations conducted at hospital two, one of the three hospitals mentioned above, between November 1992 and August 1993. Thirty-seven technicians from this group had follow-up examinations performed in April and May 1995. We reported previously on the results of their 1992 to 1993 and 1995 examinations.[19] Thirty-seven technicians from this original cohort participated in the statewide year 01/1996 to 1997 examination, and 32 of the original technicians remained active through year 04 and were examined again in 1999. Therefore, this subgroup had longitudinal follow-up data over 6 years at six time points available for study.

All examinations were conducted in a similar manner. Examinations included a detailed medical, smoking, and environmental/occupational history tailored to emergency responders; physical examination; spirometry; and routine laboratory tests.

Statistical Analyses

We used the percent of the predicted forced vital capacity (FVC)

and forced expiratory volume in 1 second (FEV_1) to adjust for the effects of age and height. We found no significant differences in the proportions of technicians (78% to 81%) and support members (19% to 22%) examined at each of the three hospitals in year 01/1996 to 1997 ($P = 0.857$). Likewise, the relative proportions of technicians (76% to 86%) to support controls (14% to 24%) remained similar among the three hospitals for year 02/1997, year 03/1998, and year 04/1999 ($P = 0.207$, $P = 0.541$, and $P = 0.614$, respectively). Among firefighters tested at hospital 1 ($n = 100$), hospital 2 ($n = 117$), and hospital 3 ($n = 112$), we found no significant differences in the year 01/1996 to 1997 mean percent predicted FVC or FEV_1 ($P = 0.087$ and $P = 0.201$, respectively). Therefore, for both of these reasons, we did not adjust for examination site in our cross-sectional or longitudinal comparisons of spirometric function.

Differences between groups at a single time point were examined using independent *t* tests and separate variances. Differences in serial mean values within groups over time were examined using analyses of variance time analyses. Differences in proportions were compared using the chi-squared or Fisher exact test, as appropriate. The level of statistical significance for all analyses was $P < 0.05$ and was two-tailed for all tests.

Results

Table 1 summarizes the baseline characteristics of the technicians and support controls at the year 01/1996 to 1997 examination. The mean age of the technicians was significantly greater ($P < 0.001$) than the mean age of the support members. Although a larger proportion of technicians than support controls had reported various pulmonary risk factors, none of these differences was statistically significant.

Of the 336 male firefighters who were either technicians or support members in year 01/1996 to 1997, 291 (87%) remained active and were examined in year 04/1999. Among 45 firefighters who left the teams for any reason or were inactive at year 04, there was no evidence of an excess dropout rate among the technicians. The proportion of technicians (78%; 35 of 45) to support controls (22%; 10 of 45) was not significantly different from among the remaining 291 members of initial cohort ($P = 0.763$). Therefore, the proportion of technicians in the initial cohort (79%; 267 of 336) and among those who remained active through year 04 (80%; 232 of 291) was quite similar.

Table 2 compares the spirometric function at the initial year 01 examination of those who remained active through year 04 compared with those who were inactive in year 04. For the technicians, those who became inactive had a significantly lower percent predicted FEV_1 ($P = 0.039$). Among technicians who became inactive, the prevalence of any pulmonary risk factor (51%; 18 of 35) was somewhat higher than among the technicians who remained active (37%; 86 of 232), but the difference was not significant ($P = 0.136$). For the support team, there were no significant differences in baseline pulmonary function between the active and inactive members. The prevalence of any pulmonary risk factor was 30% (3 of 10) among those who became inactive and 29% (17 of 59) for those who remained active ($P = 1.000$).

Among the firefighters who were technicians in year 01/1996 to 1997 and remained active with the teams through year 04/1999, the proportion with an FVC or FEV_1 that was less than 80% predicted in 1999 was 6.6% (15 of 229). This finding is similar to the proportion of technicians with an FVC or FEV_1 that was less than 80% of predicted at the start of the study, 6.1% (16 of 264). Among the firefighters who were technicians in year 01/1996 to 1997 and had an FVC or FEV_1 that was less than 80% predicted, 25% (4 of 16) had become inactive by year 04/1999. This finding compared with 12.5% (31 of 248) of those whose FVC and FEV_1 were ≥80% predicted ($P = 0.242$).

Table 3 compares the spirometric function of technicians versus support controls at each yearly examination. After the year 01/1996 to 1997 examination before the end of the study period, 15 new members joined the teams and 14 firefighters changed positions. In Table 3, fire-

TABLE 1
Baseline Characteristics of Technicians versus Support (Year 01/1996–1997)*

Variable	Technicians ($n = 267$)	Support ($n = 69$)	*P* Value
Age	40.6 ± 6.4 ($n = 252$)	35.0 ± 7.0 ($n = 68$)	<0.001
BMI	29.1 ± 4.2 ($n = 262$)	28.3 ± 3.5 ($n = 67$)	0.100
Atopy (%, *n*)	21.3, 57 of 267	17.4, 12 of 69	0.468
Smokers (%, *n*)	11.9, 29 of 244	6.9, 4 of 58	0.274
Asthma (%, *n*)	4.1, 11 of 267	1.4, 1 of 69	0.472
MD obstruction (%, *n*)	1.9, 5 of 267	1.4, 1 of 69	1.000
Sinusitis (%, *n*)	1.1, 3 of 267	0, 0 of 69	1.000
FVC% or FEV_1% pred <80% or FEV_1/FVC <70% (%, *n*)	10.6, 28 of 264	7.6, 5 of 66	0.463
% FVC% or FEV_1% pred <80% (%, *n*)	6.1, 16 of 264	4.5, 3 of 66	0.775
FEV_1/FVC <70% (%, *n*)	5.7, 15 of 264	3.1, 2 of 65	0.541
Any pulmonary risk factor† (%, *n*)	39, 104 of 267	29, 20 of 69	0.126

* BMI, body mass index; MD, medical doctor; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; pred, predicted.

† Includes any of the following: atopy, current smoking, asthma, physician diagnosis of obstruction (MD obstruction), sinusitis, FVC% < 80%, FEV_1% < 80%, or FEV_1/FVC < 70%. In preliminary analyses, all were associated with having a lower mean FEV_1% of predicted when compared with firefighters with none of these risk factors.

TABLE 2
Comparisons of Year 01 (1996–1997) Data for Active* vs Inactive† Team Members‡

Variable	Job Type	Active	Inactive	*P* Value
1996–1997 FVC (% pred)	Technician	103 ± 13 (n = 228)	100 ± 14 (n = 35)	0.171
1996–1997 FEV_1 (% pred)	Technician	103 ± 13 (n = 228)	98 ± 13 (n = 35)	0.039
1996–1997 FVC (% pred)	Support	102 ± 10 (n = 58)	108 ± 8 (n = 8)	0.064
1996–1997 FEV_1 (% pred)	Support	102 ± 13 (n = 58)	105 ± 8 (n = 8)	0.458
1996–1997 FVC (% pred)	Total	103 ± 12 (n = 286)	101 ± 13 (n = 43)	0.449
1996–1997 FEV_1 (% pred)	Total	103 ± 13 (n = 286)	99 ± 12 (n = 43)	0.082

* Remained active through year 04.
† Not active in year 04.
‡ FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; pred, predicted. Independent samples t tests.

TABLE 3
Spirometric Values of Technicians vs Support Controls*

Variable/Year	Technician	Support	*P* Value (2-tailed)
FVC (% pred)			
1996–1997	103 ± 13 (n = 263)	102 ± 10 (n = 66)	0.719
1997	102 ± 13 (n = 169)	98 ± 10 (n = 40)	0.049
1998	103 ± 13 (n = 261)	100 ± 9 (n = 60)	0.040
1999	103 ± 12 (n = 249)	98 ± 10 (n = 52)	0.003
FEV_1 (% pred)			
1996–1997	102 ± 13 (n = 263)	103 ± 12 (n = 66)	0.998
1997	103 ± 13 (n = 169)	102 ± 12 (n = 40)	0.661
1998	101 ± 14 (n = 261)	98 ± 13 (n = 60)	0.165
1999	100 ± 13 (n = 249)	96 ± 14 (n = 52)	0.041

* FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; pred, predicted. Independent samples t tests.

fighters were classified as technicians or support members based on their designated job titles at the time of the examination. The average spirometric function of the technicians was either statistically better or not significantly different from that of the support controls at all examinations.

Table 4 shows analyses of variance values for FVC and FEV_1 as a function of time. The firefighters included in Table 4 were examined in year 01/1996 to 1997, did not change job positions, remained on the teams, and were reexamined in year 04/1999. Pooled mean values are shown for all technicians, all support controls, and the total cohort. The year 02/1997 examination is not included in these time analyses because few firefighters were examined in year 02 at hospital 3 (see Methods). For percentage of FEV_1 predicted, mean values decreased by 3% for technicians, support controls, and the total cohort. Although this change was statistically significant for the technicians (P = 0.029) and the total cohort (0.014), it did not reach statistical significance for the controls (P = 0.433) likely because of the smaller sample size.

Table 5 shows mean values by job type at each examining hospital. No statistically significant changes were observed over time in these smaller sub-cohorts. It is interesting to note that within each hospital, similar trends were observed for both technicians and support members from year to year.

Table 6 shows time analyses for the team 1 technician cohort that we have followed since 1993. At year 04/1999, 80% (32 of 40) of the technicians remained active with the team. No significant changes in spirometric function were observed.

Discussion

This study was part of a longitudinal evaluation of the possible health effects of additional duties performed by firefighters on hazardous materials teams. Overall, the results suggest that hazardous materials firefighters do not lose pulmonary function at a more accelerated rate when compared with other firefighters. Hazardous materials technicians are involved with the actual assessment and mitigation of hazardous materials accidents within the hot, or contaminated, zone of the accident. Most situations are responded to on a level A basis, which entails the use of vapor-tight clothing and a positive pressure self-contained breathing apparatus. Field decontamination is routinely performed after all accidents unless the hazard poses a threat only by pulmonary absorption (eg, carbon monoxide). Although respiratory exposures to irritants are the most common exposures among victims of hazardous materials releases,[6–10] current procedures and personal protective equipment seem to be effective.

A major strength of our study was that we addressed the question of an effect on spirometric function in three ways. First, we compared cross-sectionally firefighters who were hazardous materials technicians with support firefighters who do not perform hazardous materials duty in contaminated zones. Power calculations based on the technician and support sample sizes demonstrated a 92% power to find a 5% difference in percent predicted FEV_1 or FVC between the two groups. At each of four examinations, the average spirometric function of the technicians was either statistically better or not significantly different from that of

TABLE 4
Spirometric Values by Job Type*

Variable/Job Type	1996–1997	1998	1999	Total	ANOVA *P* Value
FVC (% pred)					
Technician	103 ± 13 (*n* = 225)	103 ± 13 (*n* = 226)	103 ± 13 (*n* = 228)	103 ± 13 (*n* = 679)	0.780
Support	100 ± 10 (*n* = 46)	99 ± 9 (*n* = 47)	98 ± 10 (*n* = 46)	99 ± 10 (*n* = 139)	0.568
Total	103 ± 12 (*n* = 271)	102 ± 12 (*n* = 273)	102 ± 12 (*n* = 274)	102 ± 12 (*n* = 818)	0.621
FEV_1 (% pred)					
Technician	103 ± 13 (*n* = 225)	101 ± 14 (*n* = 226)	100 ± 13 (*n* = 228)	101 ± 14 (*n* = 679)	0.029
Support	100 ± 12 (*n* = 46)	99 ± 13 (*n* = 47)	97 ± 13 (*n* = 46)	99 ± 12 (*n* = 139)	0.433
Total	103 ± 13 (*n* = 271)	100 ± 14 (*n* = 273)	100 ± 13 (*n* = 274)	101 ± 13 (*n* = 818)	0.014

* Analysis of variance (ANOVA) time analyses. FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; pred, predicted.

TABLE 5
Mean Spirometric Values for Each Examining Hospital as a Function of Job Type*

Variable/Job Type	1996–1997	1997	1998	1999	Total	ANOVA *P* Value
FVC (% pred)						
Hospital 1						
Technician	102 ± 12 (*n* = 76)	103 ± 13 (*n* = 74)	105 ± 13 (*n* = 75)	107 ± 13 (*n* = 74)	104 ± 13 (*n* = 299)	0.113
Support	97 ± 9 (*n* = 15)	95 ± 12 (*n* = 11)	102 ± 9 (*n* = 15)	100 ± 11 (*n* = 14)	99 ± 10 (*n* = 55)	0.311
FEV_1 (% pred)						
Hospital 1						
Technician	103 ± 12 (*n* = 76)	102 ± 12 (*n* = 74)	100 ± 14 (*n* = 75)	101 ± 13 (*n* = 74)	102 ± 13 (*n* = 299)	0.644
Support	99 ± 11 (*n* = 15)	99 ± 14 (*n* = 11)	101 ± 13 (*n* = 15)	97 ± 13 (*n* = 14)	99 ± 12 (*n* = 55)	0.933
FVC (% pred)						
Hospital 2						
Technician	103 ± 11 (*n* = 77)	104 ± 12 (*n* = 68)	101 ± 11 (*n* = 76)	101 ± 11 (*n* = 78)	102 ± 11 (*n* = 299)	0.296
Support	98 ± 6 (*n* = 13)	98 ± 6 (*n* = 14)	97 ± 7 (*n* = 14)	97 ± 8 (*n* = 14)	97 ± 6 (*n* = 55)	0.958
FEV_1 (% pred)						
Hospital 2						
Technician	105 ± 13 (*n* = 77)	104 ± 12 (*n* = 68)	102 ± 12 (*n* = 76)	100 ± 13 (*n* = 78)	102 ± 12 (*n* = 299)	0.067
Support	101 ± 7 (*n* = 13)	100 ± 11 (*n* = 13)	98 ± 9 (*n* = 13)	97 ± 8 (*n* = 13)	99 ± 9 (*n* = 55)	0.793
FVC (% pred)						
Hospital 3						
Technician	105 ± 15 (*n* = 72)	94 ± 15 (*n* = 11)	102 ± 13 (*n* = 75)	100 ± 13 (*n* = 76)	102 ± 14† (*n* = 223)	0.115†
Support	105 ± 11 (*n* = 18)	84 ± 7 (*n* = 3)	99 ± 10 (*n* = 18)	97 ± 12 (*n* = 18)	100 ± 12† (*n* = 54)	0.096†
FEV_1 (% pred)						
Hospital 3						
Technician	102 ± 15 (*n* = 72)	103 ± 16 (*n* = 11)	101 ± 15 (*n* = 75)	99 ± 15 (*n* = 76)	101 ± 15† (*n* = 223)	0.400†
Support	102 ± 16 (*n* = 18)	93 ± 2 (*n* = 3)	97 ± 15 (*n* = 18)	97 ± 16 (*n* = 18)	99 ± 15† (*n* = 54)	0.527†

* Analysis of variance (ANOVA) time analyses. FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; pred, predicted.
† For Hospital 3, totals and ANOVA are for 1996–1997, 1998, 1999, and do not include 1997.

the support members. Therefore, we found no evidence of an adverse effect of hazardous materials duty in cross-sectional analyses.

Second, we performed longitudinal analyses within each group of firefighters who remained active through the fourth examination and did not change job positions during the study period. We observed no significant decrements in the percent of the predicted FVC for technicians, support controls, or the entire cohort over 3 years of follow-up. There was a small, 3% decline in the percent of the predicted FEV_1 achieved for both groups and the total cohort. This change was statistically significant for the technicians and the total cohort. It did not reach statistical significance for the referents, probably because of the smaller sample size. Thus, although the results suggested a small decline in FEV_1, this trend was not isolated to those performing hazardous materials duties.

When longitudinal changes were assessed within each hospital, no statistically significant changes were seen. For the subgroups of technicians examined at each hospital, $n =$ 72 to 77, the power to detect a 5% change in percent predicted FEV_1 or FVC was estimated at 90% or slightly higher. We noted that at any given hospital, non-significant changes of a similar magnitude from year to year were seen for both technicians and support referents. These small changes may result from testing conditions themselves such as minor differences in calibration,

TABLE 6
Spirometric Values at Baseline and Follow-Up Examinations for Team 1 Technician Cohort*

Variable	1993	1995	1996	1997	1998	1999	Total	ANOVA *P* Value
FVC (% pred)	105 ± 12 (n = 35)	106 ± 12 (n = 34)	106 ± 11 (n = 34)	106 ± 13 (n = 32)	103 ± 10 (n = 35)	102 ± 11 (n = 32)	104 ± 12 (n = 202)	0.718
FEV_1 (% pred)	107 ± 13 (n = 35)	105 ± 13 (n = 34)	109 ± 13 (n = 34)	106 ± 13 (n = 32)	104 ± 11 (n = 35)	101 ± 14 (n = 32)	105 ± 13 (n = 202)	0.215

* Analysis of variance (ANOVA) time analyses. FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second; pred, predicted.

coaching, and technique. A 6-year time analysis of a smaller cohort of technicians showed no significant changes in spirometric function.

Third, we examined loss to follow-up, which is always a concern in longitudinal studies. We compared the firefighters who dropped out before the completion of the study with the 87% who remained active through year 04. We found no excess dropout rate among technicians who engaged in hazardous materials duty compared with support members. The technicians who dropped out, however, did have a significantly lower percent predicted FEV_1 (98%) compared with 103% for those who remained active. The technicians who dropped out also had a nonsignificantly higher prevalence of pulmonary risk factors. Among the firefighters who were technicians in year 01/1996 to 1997 and had an FVC or FEV_1 that was less than 80% predicted, 25% (4 of 16) had become inactive by year 04/1999, compared with 12.5% (31 of 248) of those with FVC and $FEV_1 \geq 80\%$ predicted (P = NS). The spirometric function and prevalence of pulmonary risk factors among the support controls that became inactive were not significantly different from among those who remained active. These results are not conclusive, but they suggest a greater dropout rate from hazardous materials duty among persons with lower pulmonary function or pulmonary risk factors. Similar self-selection effects were observed in earlier studies of Boston firefighters[20,21]; those who became inactive through job transfer or retirement in the longitudinal studies had lower levels of lung function than firefighters who remained active. Nevertheless, the question remains as to whether some firefighters self-select out of hazardous materials duty or fire suppression activities because of job-related pulmonary exposures, or whether they tolerate exertion, respirator use, and other job conditions less well than the firefighters who remain active. We are limited in our ability to answer this question because exit medical examinations are not mandatory and were not undergone by those who left the teams.

The major limitation of the current study was imposed by logistical constraints. In a statewide program, all six teams could not be examined at a single hospital. Furthermore, the investigators could not require the examining hospitals to use identical spirometers, prediction equations, and techniques for all teams and all time points. Nevertheless, we found no significant differences in the year 01/1996 to 1997 mean percent of predicted FVC or FEV_1 among the three hospitals. The proportions of referent support members examined at each of the three hospitals were also quite similar. In addition, there were no significant differences in the proportions of technicians to support members among the three hospitals at any time point. These facts justified pooling the data from all three hospitals for the majority of the analyses.

An important strength of the investigation is our control group, the support team members. Both technicians and support members perform regular fire duty with their non-state, local fire departments. Support members are presumed to have a very limited potential for exposure compared with technicians, because they do not enter the hot zone of an accident. Therefore, they are an ideal control group for the investigation of potential health effects that are limited to hazardous materials duty within the contaminated zone of accidents.

The OSHA standard on hazardous waste workers requires periodic examinations at least every 2 years, but the content of the examinations is not specified. Most medical surveillance programs have included spirometry in their examination protocols[13] as recommended for hazardous waste workers[1,14,15] and firefighters.[5,16,17] Although hazardous materials duty has the potential for serious exposures and injuries from explosions, fires, and other releases of dangerous substances, few actual overexposures may occur. In previous studies of incidents responded to by the same six Massachusetts regional teams from 1990 to 1996,[6,22] hazardous materials team members reported no significant chemical exposures to themselves. Likewise, among hazardous waste workers, few significant exposures occur, because those with the greatest potential for exposure usually are equipped with the highest levels of personal protective equipment.[13] The results of the present study are consistent with these previous observations. Nonetheless, there are several strong reasons to continue annual spirometric testing for these groups. First, among unprotected victims, inhalation is the most common route of exposure associated with hazardous materials releases[6,10] and exposure to pulmonary irritants and respiratory complaints are the most common health effects.[6–10]

Therefore, group spirometric surveillance may provide one type of objective physiologic measurement of the effectiveness of safe work practices and personal protective equipment. Given the irritant nature of the most common exposures, it is not surprising that the utility of routine biochemical and hematologic testing has been limited in both hazardous waste workers[23] and hazardous materials firefighters.[24] In the future, spirometry might be complemented by the measurement of serum proteins[25] and/or sputum analytes that are markers of lung inflammation.

Other factors that support continued annual spirometry testing and longitudinal study are the relatively short period of follow-up, the high prevalence of risk factors associated with lower baseline pulmonary function, and the small excess decline in FEV_1 for the entire cohort. Although the widespread introduction and use of respiratory protection, seems to account for the lack of chronic effects in several recent studies of pulmonary function in firefighters,[20,21,26,27] acute adverse effects from occupational smoke exposure have consistently been demonstrated.[25,28–31] Finally, this study did not consider separately those firefighters with respiratory problems or other individuals possibly susceptible to accelerated losses of pulmonary function. We believe that continued study of firefighters with and without these risk factors is warranted.

Acknowledgments

The authors thank the members of Massachusetts Hazardous Materials Response Teams, the Massachusetts Hazardous Materials Response Program, the examining physicians (Drs Thomas Gassert, Thomas Hicks, Howard Hu, and Charles Sweet), and staff members of the examining hospitals (Ms Dianne Plantamura and Ms Karen Cassidy) for their continuing support of this research. Funding was provided by National Institute for Occupational Safety and Health grants OH00156 and 0H03729 for Dr Kales, and by NIOSH 0H03729, NIH ES00002, and ES05947 for Dr Christiani.

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