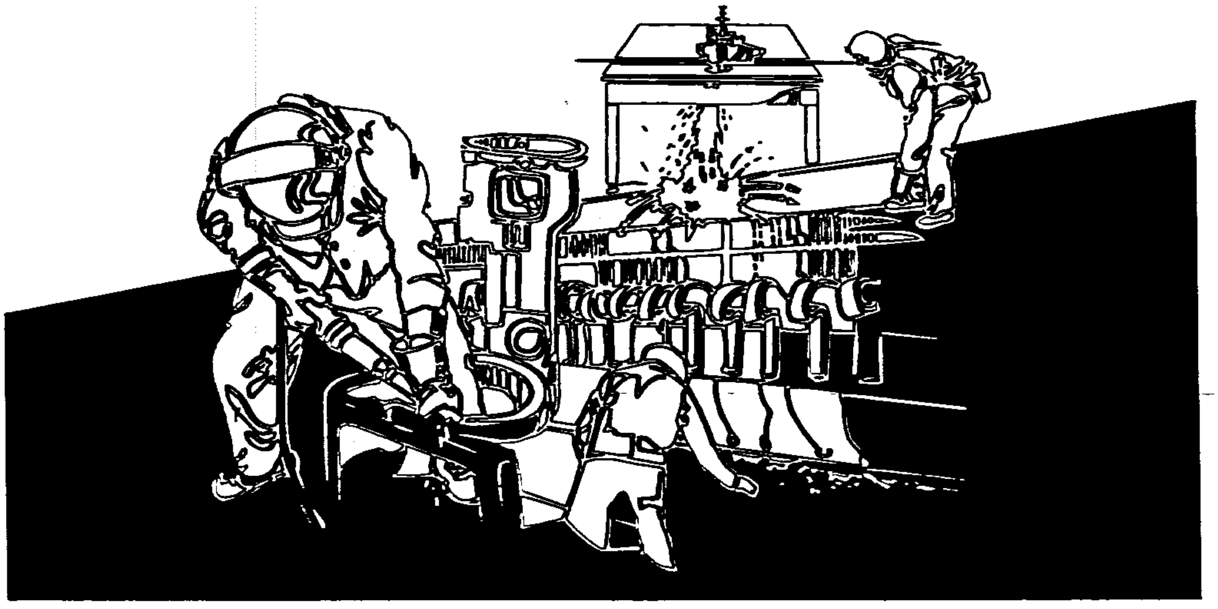
NIOSH

HEALTH HAZARD EVALUATION REPORT

HETA 91-152-2140
U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
SOUTHERN CALIFORNIA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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I. SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request from the National Park Service (NPS) to evaluate the health effects of forest fire smoke exposure among wildland fire fighters. In response to this request, investigators from NIOSH conducted a medical survey of wildland fire fighters belonging to 6 "hot shot" crews in the U.S. Department of Interior, National Park Service (NPS) and the U.S. Department of Agriculture, Forest Service (FS) on June 11-15 and on September 24-28, 1990. The survey was conducted to determine whether wildland fire fighters incurred cross-season changes in lung function and respiratory symptoms during the 1990 fire season.

During June 11-15, 1990, spirometry was performed and a questionnaire administered to 105 preseason study participants (representing 6 "hot shot" crews) to establish a preseason baseline. Postseason data were collected September 24-28, 1990, 15 weeks after baseline, on 78 individuals, representing 74% of the preseason participants. All 78 individuals completed a postseason questionnaire and were retested by spirometry. The 6 crews were divided into 3 exposure categories (low, medium, high) based on total number of hours of fighting fires weighted by a visual estimate of the intensity of smoke at each fire.

Overall, the mean cross-season changes for lung function for the 78 participants were -0.5% (95% confidence intervals [CI]: -1.1%, 0.2%) in one-second forced expiratory volume (FEV_1), 0.2% (95% CI: -0.5%, 0.9%) in forced vital capacity (FVC), -2.3% (95% CI: -4.2%,-0.5%) in the mean forced expiratory flow during the middle half of the FVC (FEF_{25-75}), and -0.5% (95% CI: -1.0%, -0.1%) in the ratio of FEV_1 to FVC (FEV_1/FVC). Dose-related decreases in FEF_{25-75} and FEV_1/FVC were observed with higher exposure (test for linearity: p=0.08 and p=0.16, respectively). Respiratory symptom prevalences did not increase significantly cross-seasonally and were not associated with exposure. The validity and applicability of these findings may be limited by several factors, including sample size, selection biases, and a non-representative fire season.

On the basis of this investigation, the NIOSH investigators conclude that there is limited evidence suggesting that forest fire fighting results in cross-season changes in lung function. A respiratory surveillance program is recommended to examine the long-term effects of forest fire fighting on lung function.

KEYWORDS: SIC 0851 (Forestry Services), forest fire fighting, lung function tests, spirometry, respiratory symptoms.

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request from the National Park Service (NPS) to evaluate the health effects of forest fire smoke exposure among wildland fire fighters. In response to this request, investigators from NIOSH conducted a medical survey of wildland fire fighters belonging to 6 "hot shot" crews in the U.S. Department of Interior, National Park Service (NPS) and the U.S. Department of Agriculture, Forest Service (FS) on June 11-15 and on September 24-28, 1990. The survey was conducted to determine whether wildland fire fighters incurred cross-season changes in lung function and respiratory symptoms during the 1990 fire season. Individual medical results of the NIOSH survey were mailed to participants in March 1991. A letter reporting the preliminary findings of the NIOSH survey, along with preliminary recommendations, was sent to the NPS requester and the 6 crew superintendents on April 3, 1991.

III. BACKGROUND

Each year, an estimated 80,000 wildland fire fighters fight approximately 70,000 forest fires that burn, on the average, 2 million acres of forested land.[1] Forest fire smoke contains a wide variety of toxic components, many of which, including particulates, formaldehyde, acetaldehyde, acrolein, furfural, sulfur dioxide, and acids, are pulmonary irritants.[1,2]

Wildland fire fighters may be exposed to smoke for long, uninterrupted periods.[1] They typically work 12-24 hour shifts for six straight days with the seventh day off. At a fire, wildland fire fighters may be on duty for two or more weeks. In addition, base camps may be located in areas of continuous smoke exposure.

The techniques used to fight forest fires are basically the same from fire to fire. Fire fighters use hand tools, chain saws and/or earth-moving equipment to remove all biomass from a given area. Thus, the fire fighters attempt to dig a fireline down to the mineral soil, and to contain the fire within these lines. In the early stages of a fire, or when a fire jumps the containment lines, direct attack is used in an attempt to suppress the fire. Usually, this consists of the use of hand tools on the leading edges of the fire to slow or alter the progress of the fire. Air attack (when water or fire retardant is dropped from various types of aircraft) is also used to slow the progress of the fire and to extinguish spot fires that may develop downwind of the main fire. Unburned land inside of the fireline may be ignited to remove fuels from areas around the advancing fire. If this burning is done to consume fuel lying in the path of the fire, it is referred to as "backfiring." If done on a smaller scale to remove fuel between the fire and the control line, it is referred to as "burning out." During these burn-outs, fire fighters are required to hold the fireline to insure that the fire does not advance into other wildland areas and/or develop into an uncontrollable fire. Once the fire is controlled fire fighters begin "mop-up" activities. Mop-up entails putting out the fire completely with the use of hand tools, chain saws, dirt, and water. Mop-up activities include digging up smoldering stumps, roots, and mineral soil and felling burning snags (a standing dead tree). Workers typically wear Nomex pants and shirts, Vibram-soled boots with 6-8 inch leather uppers, hard hats, goggles, and gloves. Some also tie a bandanna across the nose and mouth in an attempt at respiratory protection.

Firefighting crews involved in building fireline by hand consist of approximately 20 crew members (3 sawyers, 3 swampers who assist the sawyers, and the rest of the fire fighters are equipped with hand tools). These crews are classified as either Type I or Type II crews. Type I crews, also referred to as "hotshots", are highly trained crews used primarily in hand fireline construction in direct attack. Type II crews are also used in hand fireline construction, but relied on for mop-up activities.

In 1987, smoke inhalation accounted for 38% of all reports of injuries and illnesses among all fire fighters in California.[1] A California Department of Health Services (CDHS) study of 94 wildland fire fighters engaged in the Klamath National Forest fires of 1987 found that 76% reported respiratory symptoms (i.e., cough, wheezing or shortness of breath).[3] During the 1988 Yellowstone fires, 40% of the approximately 30,000 medical visits made by wildland fire fighters were for respiratory problems.[1] This information suggests that wildland fire fighters experience significant rates of acute smoke inhalation.

IV. METHODS

A. Study Objective

The primary study objective was to determine if wildland fire fighters experienced cross-seasonal changes in lung function and respiratory symptoms after a season of forest fire fighting. Four specific research questions were examined.

1. Was there a cross-seasonal change in lung function?
2. Was there a cross-seasonal change in respiratory symptoms?
3. Is there an association between percent change in lung function and exposure category?
4. Is there an association between respiratory symptoms and exposure category?

B. Study Population

The population eligible for this investigation was the wildland fire fighters belonging to 6 "hot shot" crews in the NPS and the FS. The 6 "hot shot" crews were stationed in Southern California during the 1990 fire season. There were 111 wildland fire fighters present at the time of the preseason testing. Informed consent was obtained from all 111 wildland fire fighters; however, one individual who completed the preseason questionnaire declined the pulmonary function test. Later, it was discovered that 5 other wildland fire fighters were temporarily assigned (only for approximately 2 weeks) to one of the 6 "hot shot" crews and therefore were considered ineligible. This left a total of 105 preseason participants (99% of those eligible).

C. Data Collection

During June 11-15, 1990, spirometry was performed and a questionnaire administered to study participants to establish a preseason baseline before significant smoke exposure occurred. The questionnaire used was a revision of one developed by the California Department of Health Services, Occupational Health Program, for studies of wildland fire fighters. The questionnaire asked for information regarding demographics, smoking history, medical and occupational history, recent work exposures, and respiratory symptoms. In addition to the respiratory symptom questions, which were based on the standardized respiratory questionnaire prepared by the American Thoracic Society (ATS),[4] the questionnaire asked the number of days in the previous seven days that the participant had experienced eye irritation or upper and lower respiratory symptoms. The questionnaire was self-administered then reviewed with one of the NIOSH investigators.

Spirometry was performed by trained technicians using two Sensormedics Model 827 volume spirometers interfaced with an in-house built computer; American Thoracic Society procedures[5] were followed. The spirometers were calibrated with a 3-liter syringe before each testing session. Each participant performed a minimum of 5 forced expiratory maneuvers. Preseason and postseason spirometry for each participant was performed using the same spirometer and by the same technician. Spirometric values were considered reproducible when the two best values for both one-second forced expiratory volume (FEV_1) and forced vital capacity (FVC) did not vary by more than 5% or 100 milliliters (ml), whichever was greater.

Two individuals did not meet the reproducibility criterion for FEV_1 during the preseason testing, and one individual did not meet the reproducibility criterion for FVC during postseason testing.

These individuals were not excluded from analysis, however, since spirometry variability has been associated with impaired lung function, and exclusion would thus tend to bias the analysis toward a falsely negative result.[6,7] In addition, 3 individuals preseasonally and 4 individuals postseasonally did not meet the ATS acceptability criterion for effort lasting 6 seconds; however, in each case, at least 3 spirograms had reached a plateau for at least 2 seconds by the end of effort and, therefore, were included in the analysis.

All spirometric measurements were corrected to body temperature and pressure, saturated with water vapor (BTPS) using a dynamic BTPS correction factor model developed by Hankinson et. al.[8] This model was used to correct for cross-season spirometer temperature differences that can result in an error in spirometric values.[8] Preseason spirometer temperatures were generally lower than postseason spirometer temperatures. Corrected spirometric values were compared to predicted values calculated for age, sex, height, and race. Each participant's height was measured in stocking feet. Predicted values were calculated using the equations of Knudson;[9] an additional multiplier of 0.85 was applied to the predicted FEV_1 and FVC for Blacks and Asians.[10] To assess cross-season changes in pulmonary function, the percent change across the fire season was calculated for FEV_1, FVC, the mean forced expiratory flow during the middle half of the FVC (FEF_{25-75}), and the ratio of FEV_1 to FVC (FEV_1/FVC) for each participant as follows:

For FEV_1, FVC, and FEF_{25-75}:

Percent change (%) = 100 X (postseason - preseason)/preseason

For FEV_1/FVC:

Percent change (%) = postseason - preseason

Postseason data were collected September 24-28, 1990, 15 weeks after baseline, on 78 individuals, representing 74% of the preseason participants. All 78 individuals completed a postseason questionnaire (modified version of preseason questionnaire with demographic and occupational history sections omitted) and were retested by spirometry. The 27 individuals who were unavailable for postseason testing had terminated employment early. Although one of these 27 was reported to have had an episode of "smoke inhalation" requiring a visit to an emergency room, none of them had terminated employment because of pulmonary complaints; they had left to attend school, to start another job, for personal reasons, or because they had been physically injured.

D. Exposure Estimation

An exposure questionnaire was developed to obtain information on the fires that each of the 6 crews fought during the season. The 6 crew superintendents or their foremen completed one questionnaire for each fire. The information collected included the name and location of the fire, the total number of hours of fire fighting, and whether there was any known exposure to hazardous substances (other than burning trees and vegetation). They were also asked to rate the intensity of the smoke on the fireline using a scale of one to five, with one representing light smoke and five representing heavy smoke. An adjusted number of hours of smoke exposure was calculated for each fire by multiplying the total number of hours of fire fighting at a particular fire by the smoke intensity rating for that fire.

The adjusted hours of smoke exposure at each fire were totaled by crew to obtain total adjusted hours of smoke exposure for the season for each of the 6 crews. Based upon the total adjusted hours of smoke exposure for the season, crews were divided, based on obvious break points, into 3 exposure categories: low, medium, and high (Table 1).

E. Rationale of Exposure Estimation Technique

For logistical reasons, industrial hygiene sampling over the entire fire season of the study population was not considered feasible. However, duration of exposure, measured in the number of hours of fire fighting, was obtainable from existing fire log records and regarded as a reasonable estimate of smoke exposure. The number of hours of fire fighting by the crew was recorded daily on fire log records. Fire log records were considered to be reasonably accurate and up-to-date, as they were also used to calculate pay.

The number of hours of fire fighting was weighted by intensity of smoke on the fireline to account for differences in smoke conditions. The intensity of smoke on the fireline was rated by crew superintendents and foremen, who had many years of wildland fire fighting experience.

The justification for assigning each member of a particular crew to the same exposure category was that all crew member's hours of fire fighting would closely approximate each other's since they were dispatched together and worked as a team. In addition, crew members worked in relatively close proximity to each other and therefore tended to be exposed to similar conditions that affect fire fighters' smoke exposures, such as fuel type, terrain, and prevailing meteorologic conditions.

F. STATISTICAL ANALYSIS

Data analyses were performed using SPSS for the IBM PC/XT/AT (SPSS Inc., Chicago, IL).[11] Descriptive statistics were used to evaluate demographic characteristics. Non-parametric analyses (McNemar and Wilcoxon matched paired signed ranks) were used to compare the differences between preseason and postseason respiratory symptoms. The relationship between percent change in lung function values and exposure category was tested by analysis of variance (ANOVA) and test for linearity. The relationship between respiratory symptoms and exposure category was tested by chi-square and chi-square for linear trend. The effects of potential work-related risk factors (number of seasons of fire fighting, days since last fire, and employment status [full-time vs seasonal]), as well as potential confounders (age, sex, race, smoking status [never vs former vs current], history of asthma, and history of allergy) were assessed by linear regression (for lung function tests) and logistic regression (for respiratory symptoms). No significant associations were found on regression analyses, so results reported here will be limited to chi-square and ANOVA analyses.

V. EVALUATION CRITERIA

Lung Function Tests

Lung function tests that measure how well the lungs and air passages move air in and out include, among others:

a. Forced vital capacity (FVC), the total amount of air one can force out of the lungs after breathing in as deeply as possible;

b. One-second forced expiratory volume (FEV_1), the amount of air one can breathe out in the first second of an exhalation;

c. The mean forced expiratory flow during the middle half of the FVC (FEF_{25-75}), the average rate of air flow in the middle of a forcefully exhaled breath; and

d. The calculated ratio of FEV_1 to FVC (FEV_1/FVC).

Lung function values are evaluated by comparing them to "predicted" values that take into account age, height, sex, and race. Lung function is considered "normal" if the FVC and FEV_1 are 80% or more of their predicted values and FEV_1/FVC is 70% or more. Interpretation of the FEF_{25-75} is more difficult as there is wide variation among apparently healthy individuals. As a rough guide, FEF_{25-75} as low as 60% of predicted may be within the acceptable range.

A low FEV_1/FVC, or a low FEV_1 with a normal FVC, indicates an "obstructive" impairment to exhaling air rapidly. A low FVC, with a normal FEV_1/FVC, indicates a "restrictive" impairment of lung capacity. Other combinations are more difficult to interpret without additional information. A low FEF_{25-75} indicates small airways obstruction.

VI. RESULTS

A. Comparability of Preseason and Preseason and Postseason Participants

To assess the potential for selection bias, the fire fighters with cross-season data were compared with those who participated only in the preseason survey (and were therefore not included in the cross-season analyses). Characteristics of the 27 participants with only preseason data and the 78 participants with both preseason and postseason data are presented in Table 2. The group with both preseason and postseason data were older and worked significantly more seasons of fire fighting than the group with only preseason data. This makes sense, since several wildland fire fighters who terminated employment early did so to return to school. The two groups were not significantly different with respect to sex, race, employment status (full-time vs seasonal), smoking history (never vs former vs current), or history of asthma and allergy.

In both groups, mean preseason (baseline) FVC and FEV_1 were greater than predicted values; FEF_{25-75} and FEV_1/FVC measurements were close to predicted values (Table 2). The individuals who participated in both preseason and postseason testing had slightly lower baseline percent predicted values of FVC ($p=.03$) and FEV_1 ($p=.07$) than the group evaluated only preseasonally.

The results that follow are for the 78 participants with both preseason and postseason data.

B. Demographic, Medical History and Occupational Characteristics

Characteristics of the 78 participants with preseason and postseason data are presented in Table 2. Eighty-six percent of the participants were male and 64% were Caucasian. Participants' mean age was 27 years (standard deviation [sd]=7), and they had worked an average of 6 seasons (sd=6) fire fighting. Seventy-two percent were seasonal employees. Eighty-one percent had never smoked. A history of allergies was reported by 30% of the participants. Nine percent reported a history of asthma.

The 78 participants were compared by exposure category (Table 3). The groups were similar for each of the demographic variables evaluated except race; 58% of the low-exposure group, 83% of the medium-exposure group, and 48% of the high-exposure group were Caucasian. More importantly, the exposure groups differ with respect to Native Americans, the racial group for which spirometric predicted values are least well established. (This would not affect cross-season data, however.)

C. Baseline Lung Function

Preseason mean percent predicted values of the participants were compared by exposure category (Table 3). There was no difference in baseline (preseason) FEV_1 and FVC across exposure categories. The preseason FEF_{25-75} and FEV_1/FVC ratio were highest among the high exposure category (by ANOVA).

D. Cross-Season Changes

1. Lung Function

Overall, the mean cross-season changes for lung function for the 78 participants were -0.5% (95% confidence intervals [CI]:-1.1%, 0.2%) in FEV_1, 0.2% (95% CI: -0.5%, 0.9%) in FVC, -2.3% (95% CI: -4.2%, -0.5%) in FEF_{25-75}, and -0.5% (95% CI: -1.0%, -0.1%) in FEV_1/FVC. The mean cross-season changes in lung function by exposure category are presented in Table 4. Greater decreases in FEF_{25-75} were observed with increasing exposure (test for linearity: p=.08). The mean changes in FEV_{25-75} for low-, medium-, and high-exposure groups were -0.5%, -1.9%, and -4.7%, respectively. Less pronounced dose-related decreases in FEV_1/FVC were observed with increasing exposure (test for linearity: p=0.16). As assessed by linear regression, lung function changes were not associated with number of seasons of fire fighting, days since last fire, or age. There was no difference in mean cross-season changes in FEV_1, FVC, FEF_{25-75}, or FEV_1/FVC between those participants with, and those without a history of asthma (Table 5).

2. Symptoms

The numbers of fire fighters reporting, during the preceding week, eye irritation, nose irritation, and shortness of breath declined over the season (Table 6). The number of fire fighters reporting throat irritation, cough, phlegm, wheezing, and chest tightness changed little.

Among the participants who reported symptoms, the average number of days experiencing symptoms within the previous week is shown in Table 7. As assessed by the McNemar test for matched pairs, there was no significant increase in the prevalence of any of the respiratory symptoms. As assessed by the Wilcoxon matched-pairs-signed-ranks test, there was no significant increase in the number of days with any of the respiratory symptoms.

Study participants who developed respiratory symptoms over the season (i.e., those who did not report the symptom preseasonally but did postseasonally) were examined by exposure category (Table 8). Development of throat irritation was observed with increasing exposure (p=0.13). Otherwise, development of respiratory symptoms over the season was not observed with higher exposure.

VII. DISCUSSION

There is limited evidence suggesting that wildland fire fighting results in cross-season changes in lung function. In this study, wildland fire fighters experienced a significant cross-season decline in FEF_{25-75} and FEV_1/FVC. When the study group was divided into three exposure categories, dose-related decreases in FEF_{25-75} and FEV_1/FVC were associated with higher exposure, although these associations did not achieve statistical significance at the $p<0.05$ level.

FEV_1 and FEV_1/FVC assess airflow in the large airways. FEF_{25-75} reflects changes in the peripheral airways (smaller bronchi and bronchioles), where diseases of chronic airflow obstruction are thought to begin.[13] Cross-shift lung function studies do not usually report effects on FEF_{25-75}, probably because of its large variability in the same individual and between individuals. However, it may be a useful measurement for detecting early obstructive airway disease at a stage when the FEV_1 and FEV_1/FVC are normal.[13]

Two studies of wildland fire fighters have reported cross-seasonal declines in lung function.[14,15] Researchers from Johns Hopkins University found a significant cross-season decline in FEV_1 of -1.2%.[14] Cross-season declines in FEV_1 and FVC were significantly associated with increasing hours of fire fighting in the final week of the study. A California Department of Health Services, Occupational Health Program study of wildland fire fighters found significant cross-seasonal declines in FVC, FEV_1, FEF_{25-75}, and FEV_1/FVC.[15]

The lung functioning of structural fire fighters has been studied more extensively than that of wildland fire fighters.[16-23] Structural and wildland fires produce many similar toxic substances, including particulates, aldehydes, and acids. Wildland and structural fires each have their own unique exposures: combustion products from synthetic substances in structural fires, and vegetative resinous combustion products in wildland fires. Structural fire fighters generally use a self-contained breathing apparatus, whereas no effective respiratory protection is used by wildland fire fighters. The bandanna used by some fire fighters provides the wearer with little to no degree of protection from the toxic substances in the smoke.

Acute decrements in lung function among structural fire fighters after smoke inhalation have been documented.[16-18] Studies evaluating the chronic effects of smoke inhalation on FEV_1 and FVC among structural fire fighters have shown inconsistent findings.[19-23] A recent study of respiratory mortality among structural fire fighters found an increased risk of dying from non-malignant respiratory diseases.[24] Our study found a dose-related decrease in FEF_{25-75} with higher exposure. Few lung function studies of structural fire fighters have reported the effects of smoke exposure on FEF_{25-75}. Two studies that evaluated changes in FEF_{25-75} from chronic smoke exposure found no significant difference between structural fire fighters' measurements and their matched controls.[25,26]

VIII. STUDY LIMITATIONS

Our study had several limitations. The number of fire fighters with cross-season data may have been enough to evaluate the relationship of forest fire smoke exposure and subtle changes in lung function and respiratory symptoms.

Our results may not reflect the actual chronic effect on lung function of a season of forest fire fighting. According to crew members' accounts, the 1990 fire season was not a representative season for smoke exposure. Crew superintendents reported significantly fewer hours of fire fighting than in previous seasons. One explanation offered for this was that California crews were dispatched to fewer out-of-state fires because of expectations of large California fires (due to several years of drought conditions).

Pre-fire fighting lung function values were not available on the study participants. Preseason lung function results were used to represent a fire fighter's baseline. Possibly, a greater change in lung function would have been observed if fire fighters' preseason and postseason spirometric values could have been compared to their "true" baseline. Using preseason spirometric values as a fire fighter's baseline may have underestimated the actual effect of chronic smoke exposure on lung function, since the effect of only 1 season could be studied.

The exposure variable used in this study may be only crudely associated with participants' actual exposure to pulmonary irritants, and some misclassification of participants by exposure category may have occurred. The study may also have been limited by a healthy worker effect. Wildland fire fighters who left fire fighting employment because of respiratory problems (although that may not have been the "official" reason) were not evaluated in this study. This could have underestimated the association between forest fire smoke exposure and respiratory effects.

IX. RECOMMENDATIONS

This study of lung function in wildland fire fighters indicates that changes may occur over a single season of forest fire fighting. To determine if these changes in lung function are cumulative or if there is recovery between the fire seasons, longitudinal studies to assess the long-term respiratory effects of chronic smoke exposure may be useful. The establishment of a comprehensive respiratory surveillance program could provide the necessary data to assess the long-term respiratory effects of forest fire fighting. Components of a respiratory surveillance program should include (but need not be limited to) a respiratory and occupational history and spirometric testing according to ATS standards.

Practical and effective methods to protect fire fighters from smoke exposure need to be developed. Environmental data can assist in this long-range goal by characterizing exposures to wildland fire fighters and identifying fire fighting activities that are associated with high exposure levels.

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6. Crew Superintendent, El Cariso Hot Shots
7. Crew Superintendent, Horseshoe Meadow Hot Shots
8. NIOSH Denver Region
9. OSHA Region IX
10. All study participants
11. Fire Management Specialist, National Park Service
12. Physical Scientist, Forest Service
13. Chairman, National Wildfire Coordinating Group Technical Panel
14. Director, California Department of Health Services, Occupational Health Program

Table 1

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

STUDY PARTICIPANTS

Crew	Adjusted Hours [1]	Exposure Category	# Fire Fighters
A	1911	High	10
B	1838	High	15
C	1509	Medium	17
D	1524	Medium	12
E	951	Low	12
F	996	Low	12

[1] total adjusted hours of smoke exposure for the season (for each fire, the number of hours multiplied by smoke intensity rating (1 to 5))

Table 2

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

CHARACTERISTICS OF WILDLAND FIRE FIGHTERS BY FOLLOW-UP STATUS

Characteristics	Follow-Up Status: Preseason Only	Follow-Up Status: Pre- & Postseason	p Value[1]
Number of Participants	27	78	
Age [mean, (sd[2])]	24 (4)	27 (7)	0.06
Gender (% male)	89 %	86 %	0.95
Race:			0.07
% Caucasian	70 %	64 %	
% Hispanic	11 %	17 %	
% Native American	4 %	17 %	
% Black	11 %	1 %	
% Asian/Pacific Islander	4 %	1 %	
Employment Status:			
% seasonal	85 %	72 %	0.26
# fire seasons [mean, (sd)]	3 (3)	6 (6)	0.02
Smoking Status:			0.55
% never smokers	74 %	81 %	
% former smokers	11 %	11 %	
% current smokers	15 %	8 %	
Medical History:			
% asthma	7 %	9 %	0.99
% allergy	22 %	30 %	0.63
Preseason Lung Function [mean, (sd)]:			
FEV_1 % predicted	109 (13)	104 (13)	0.07
FVC % predicted	115 (14)	109 (12)	0.03
FEF_{25-75} % predicted	97 (20)	98 (27)	0.90
FEV_1/FVC % predicted	96 (7)	96 (7)	0.73

[1] p Value: the probability that the association occurred by chance. A p value of less than 0.05 is often considered "statistically significant." Chi-square test was used for dichotomous variables and analysis of variance (ANOVA) for continuous variables.
[2] sd = standard deviation

Table 3

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

CHARACTERISTICS OF WILDLAND FIRE FIGHTERS BY EXPOSURE CATEGORY

Characteristics	Exposure Category Low	Medium	High	p Value[1]
Number of Participants	24	29	25	
Age [mean, (sd[2])]	25 (7)	28 (8)	27 (5)	0.30
Gender (% male)	96 %	86 %	76 %	0.14
Race:				0.03
% Caucasian	58 %	83 %	48 %	
% Hispanic	8 %	17 %	24 %	
% Native American	29 %	0 %	24 %	
% Black	0 %	0 %	4 %	
% Asian/Pacific Islander	4 %	0 %	0 %	
Employment Status:				
% seasonal	71 %	83 %	60 %	0.18
# fire seasons [mean, (sd)]	5 (7)	6 (7)	6 (5)	0.83
Smoking Status:				0.58
% never smokers	92 %	76 %	76 %	
% former smokers	4 %	14 %	16 %	
% current smokers	4 %	10 %	8 %	
Medical History:				
% asthma	4 %	14 %	8 %	0.46
% allergy	17 %	36 %	36 %	0.25
Preseason Lung Function [mean, (sd)]:				
FEV_1 % predicted	104 (12)	102 (11)	108 (15)	0.25
FVC % predicted	108 (12)	109 (11)	108 (13)	0.88
FEF_{25-75} % predicted	96 (22)	88 (24)	111 (30)	0.006
FEV_1/FVC % predicted	96 (6)	93 (7)	99 (6)	0.005

[1] p Value: the probability that the association occurred by chance. A p value of less than 0.05 is often considered "statistically significant." Chi-square test was used for dichotomous variables and analysis of variance (ANOVA) for continuous variables.
[2] sd = standard deviation

Table 4

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

CROSS-SEASON CHANGES IN LUNG FUNCTION BY EXPOSURE CATEGORY

Lung Function	Exposure Category Low	Medium	High	p Value[1]
Number of Participants	24	29	25	
FEV_1	- 0.2 %	0.0 %	- 1.4 %	0.12
FVC	0.0 %	0.6 %	- 0.2 %	0.86
FEF_{25-75}	- 0.5 %	- 1.9 %	- 4.7 %	0.08
FEV_1/FVC	- 0.2 %	- 0.4 %	- 1.0 %	0.16

[1] Test for linearity: p Value represents the probability that the association occurred by chance. A p value of less than 0.05 is often considered "statistically significant."

Table 5

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

CROSS-SEASON CHANGES IN LUNG FUNCTION BY HISTORY OF ASTHMA

Lung Function	History of Asthma Yes	History of Asthma No	p Value[1]
Number of Participants	7	71	
FEV_1	- 0.8 %	- 0.5 %	0.75
FVC	- 0.6 %	0.2 %	0.49
FEF_{25-75}	1.9 %	- 2.8 %	0.16
FEV_1/FVC	- 0.2 %	- 0.6 %	0.62

[1] Analysis of Variance (ANOVA): p Value represents the probability that the association occurred by chance. A p value of less than 0.05 is often considered "statistically significant."

Table 6

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

FREQUENCY OF SYMPTOMS
[Number (%)]

Symptoms	Preseason	Postseason
eye irritation	22 (28%)	12 (15%)
nose irritation	37 (47%)	32 (41%)
throat irritation	17 (22%)	16 (21%)
cough	23 (30%)	25 (32%)
phlegm	20 (26%)	21 (27%)
wheezing	9 (12%)	10 (13%)
shortness of breath	9 (12%)	5 (6%)
chest tightness	6 (8%)	4 (5%)

Table 7

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

AVERAGE NUMBER OF DAYS REPORTING SYMPTOMS [1]
[Mean (sd[2])]

Symptoms	Preseason	Postseason
eye irritation	2.5 (1.7)	2.6 (1.6)
nose irritation	3.6 (2.0)	3.8 (2.2)
throat irritation	2.8 (1.3)	3.0 (2.1)
cough	3.7 (1.9)	3.9 (2.0)
phlegm	3.5 (2.3)	4.3 (2.1)
wheezing	2.8 (1.7)	2.4 (1.8)
shortness of breath	1.9 (1.0)	2.8 (2.4)
chest tightness	2.5 (1.5)	2.7 (2.1)

[1] Mean number of days reporting symptoms in previous week

[2] sd = standard deviation

Table 8

U.S. National Park Service
U.S. Forest Service
Wildland Fire Fighters
HETA 91-152

June and September, 1990

CROSS-SEASON CHANGES IN RESPIRATORY SYMPTOMS BY EXPOSURE CATEGORY
[Number (%)]

Symptoms	Exposure Category Low	Medium	High	p Value[1]
Number of Participants	24	29	25	
eye irritation	0 (0%)	3 (10%)	1 (4%)	0.65 [2]
nose irritation	7 (29%)	3 (10%)	4 (16%)	0.24
throat irritation	2 (8%)	4 (14%)	6 (24%)	0.13
cough	4 (17%)	7 (24%)	6 (24%)	0.54
phlegm	8 (33%)	3 (10%)	3 (12%)	0.06
wheezing	2 (8%)	2 (7%)	2 (8%)	0.97
shortness of breath	0 (0%)	1 (3%)	2 (8%)	0.31 [2]
chest tightness	2 (8%)	2 (7%)	0 (0%)	0.30 [2]

[1] Chi-square for linear trend: p Value represents the probability that the association occurred by chance. A p value of less than 0.05 is often considered "statistically significant."

[2] Because of small numbers, the value "1" was added to each cell in order to compute the p value.