Lipid Profile of Firefighters Over Time: Opportunities for Prevention

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Heart disease is the primary cause of on-duty deaths in firefighters, but little is known about their lipid profile. We evaluated the lipid profile in relation to other cardiovascular disease risk factors in 321 firefighters at a baseline examination. Prospective comparisons were performed for 285 firefighters, who were enrolled in a statewide medical surveillance program, and had complete follow-up data for 4 years. The average cholesterol level in firefighters declined from 224 mg/dL at baseline (1996–1997) to 214 mg/dL at the follow-up examination ($P < 0.0001$). Conversely, both obesity (body mass index ≥ 30; 34% versus 40%, $P = 0.008$) and triglycerides (≥200 mg/dL; 27% versus 35%, $P = 0.047$) increased over time. The proportion of firefighters taking lipid-lowering medications increased from 3% at baseline to 12% at follow-up ($P < 0.0001$). Cholesterol levels declined significantly, and treatment rates for elevated cholesterol increased over time. Despite repeated examinations, a considerable number of firefighters had persistently elevated cholesterol, and only a minority were receiving adequate treatment. (J Occup Environ Med. *2002;44:840–846*)

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Cholesterol screening has long been established as a recommended preventive measure for particular groups as well as the general population. According to the recently published report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III [ATP III]), all adults 20 years of age or older should undergo a fasting lipoprotein profile test at least once every 5 years.[1,2]

Screening for cardiovascular disease risk factors in general and blood cholesterol in particular has been promoted in the context of workplace wellness programs, surveillance examinations, and fitness-for-duty evaluations.[3–7] Several studies have been conducted in occupational settings, such as airforce and commercial pilots,[8,9] office workers,[10] bus and truck drivers,[11] and other groups of workers. However, few studies have been reported on the lipid profile of firefighters.[12,13] We reported previously the cholesterol levels of hazardous-materials firefighters at a baseline examination undertaken in 1996 at the initiation of a prospective surveillance program.[14,15]

The objectives of the current report were to describe the population distribution of lipids in our occupational group according to the updated NCEP guidelines and to evaluate the longitudinal changes of the lipid profile of the hazardous-materials firefighters. In addition, we sought to explore the possible benefits of participating in an occupational surveil-

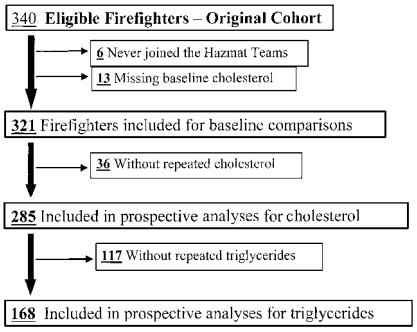

Fig. 1. Sample sizes and exclusion criteria for the different statistical comparisons.

lance program in terms of detection, evaluation, and treatment of high cholesterol.

Methods

Study Sample

The study population consisted of 340 members of six regional hazardous-materials teams in the Commonwealth of Massachusetts who underwent a baseline medical examination in 1996 or 1997 when a statewide medical surveillance program was initiated. These firefighters included 268 hazardous-materials technicians and 72 support members. The firefighters joined the hazardous-materials teams on a contractual basis in addition to their primary occupational duties as municipal firefighters in local fire departments. A total of 19 firefighters were excluded altogether from the study sample. Thirteen firefighters were excluded because they did not have baseline cholesterol values, two firefighters were excluded because they had a medical examination but never joined a hazardous-materials team, three were excluded because of inadequate follow-up information, and one firefighter who was already on "injured-on-duty" status at his baseline examination was also excluded. The breakdown of the entire study population is summarized in Fig. 1.

We evaluated the lipid profile in relation to other cardiovascular disease risk factors in 321 firefighters at a baseline examination. Thirty-six firefighters were not included in the prospective analyses. Eight firefighters did not have follow-up examination in 2000 because of injured-on-duty status. Twenty-eight firefighters either did not undergo blood cholesterol testing at follow up, their drawn blood sample was not suitable for analysis, or the results were not documented appropriately. Thus, a subsample of 285 firefighters who had cholesterol data at both the baseline and the follow-up examinations was used to make comparisons over time. For the comparison of serum triglyceride levels over time, we included 168 firefighters who had triglyceride levels at both examinations. Many firefighters had missing triglyceride levels because one of the contracted hospitals did not perform the serum triglyceride test on the participating firefighters at the baseline examination.

The Institutional Review Boards of the Harvard School of Public Health, Olympus Specialty and Rehabilitation Hospital, and the Cambridge Hospital all approved review of the medical records for research purposes. The examination and all results were confidential.

Baseline and Follow-Up Medical Examinations

Medical surveillance examinations were performed at one of three contracted Massachusetts hospitals. The baseline examinations for most of the firefighters took place in 1996 (82%) and the remainder in 1997. The subsequent medical examinations for the total study sample took place during the fall of 1998, 1999, and 2000. The examinations were done for the dual purposes of medical surveillance and for fitness-for-duty determination for the state hazardous-materials teams. All examinations were conducted in a similar fashion and followed a written protocol. Examinations included a detailed medical and occupational/environmental history, a physical examination, and routine laboratory tests, but not medical treatment. The firefighters were notified of their laboratory results at every examination and were encouraged by the examiners to consult their own primary care physicians for further evaluation and/or management of any abnormal values. Summary results for each firefighter's examination were submitted to a computerized medical record repository.

Blood Lipid Measurements

During the baseline examination in 1996 or 1997, blood cholesterol was measured for all participating subjects at all three hospitals, whereas at two hospitals subjects underwent additional testing for serum triglyceride levels. During the year 2000 examination, all subjects underwent a complete lipid profile evaluation, which included total cholesterol, serum triglycerides, and low-density and high-density lipoprotein (LDL, HDL) cholesterol. Lipid profile results for each examination were documented on each firefighter's summary sheet and sent to the medical record repository. The firefighters were assigned to the different categories of blood cholesterol levels according to the ATP III classification (normal cholesterol, <200 mg/dL; borderline-high cholesterol, ≥ 200 but <240 mg/dL; high cholesterol, ≥ 240 mg/dL).[1] The tests on blood cholesterol and serum triglycerides were random (nonfasting) because firefighters were scheduled for the annual examinations during working hours throughout the day.

Additional Risk Factors

Prospective information on several other factors was also collected routinely at every examination and entered into the computerized repository. These factors included age, sex, height, weight, allergies, medications, smoking history, and physical examination findings. A number of clinical tests, including a routine electrocardiogram, spirometry, and visual and acoustic acuity tests, were also performed. Finally, a broad range of laboratory tests were administered at each annual examination.

TABLE 1
Distribution of Cardiovascular Disease Risk Factors in Hazardous-Materials Firefighters by Total Cholesterol Level at the Baseline Examination

Risk Factors	*n*	Total Cholesterol <240 mg/dL (n = 211) Percent (*n*)	Total Cholesterol ≥240 mg/dL (n = 110) Percent (*n*)	*P* Value
Age ≥ 45 years	321	21.3 (45)	32.7 (36)	0.02
Smoking	321	8.1 (17)	11.8 (13)	0.27
Hypertension*	321	18.0 (38)	25.4 (28)	0.12
BMI ≥ 30 kg/m^2	321	28.9 (61)	46.4 (51)	0.002
Triglycerides ≥ 200 mg/dL	202	17.6 (23)	52.1 (37)	<0.0001
Mean blood glucose (mg/dL) (±SD)	146	96.7 (±28.2)	96.6 (±12.6)	0.97

* According to the Joint National Committee-VI guidelines. "Hypertension" includes firefighters with high blood pressure or those taking antihypertensive medications.

TABLE 2.
Comparison of Total Cholesterol and Triglycerides in Hazardous-Materials Firefighters at Baseline and Follow-Up Examinations

	n	Baseline Examination (1996–1997)	Follow-Up Examination (2000)	*P* Value
Total cholesterol (mg/dL)				
Mean (±SD)	285	224 (±39)	214 (±36)	<0.0001*
<200 (% normal)		30.5	35.8	
200–239 (% borderline-high)		36.1	42.8	
≥240 (% high)		33.3	21.4	<0.0001†
Triglycerides (mg/dL)				
Mean (±SD)	168	165 (±109)	175 (±97)	0.22*
<150 (% normal)		54.2	45.8	
150–199 (% borderline high)		18.4	19.1	
200–499 (% high)		26.8	33.9	
≥500 (% very high)		0.6	1.2	<0.0001†

* *P* value for paired *t* test.
† *P* value for chi-square test by the GENMOD procedure.

These tests included complete blood count and biochemical measurements (blood glucose, liver enzymes, serum creatinine, etc).

Statistical Analyses

Statistical analyses were performed using SAS software (version 6.12; SAS Institute, Cary, NC).[16] *t* Tests and chi-square tests were used to compare possible differences between firefighters with high versus low cholesterol in standard cardiovascular disease risk factors (age, smoking, hypertension, and body mass index [BMI]) at baseline. Comparisons between those who underwent the blood tests and those with missing data were performed to evaluate possible significant differences.

Additional comparisons were also made between the cholesterol or triglyceride levels of firefighters at baseline with the corresponding levels at the year 2000 follow-up examination (paired *t* test, McNemar's test). The GENMOD procedure was used to make comparisons for the categorical variable of cholesterol and triglycerides. The level of significance was 0.05, and all tests were two-sided.

Results

A total of 321 firefighters were included in our analyses. The mean age of the study participants at baseline was 39 years (range, 22–58 years), and almost all of them were men (n = 317). The mean total cholesterol level at the baseline examination was 224 mg/dL. The distribution of cardiovascular disease risk factors by different cholesterol categories in the firefighters at baseline is shown in Table 1. Firefighters with high cholesterol values were older and were more likely to have higher BMIs and higher serum triglyceride values when compared with those with lower cholesterol values. The prevalence of smoking and hypertension was also greater in the high-cholesterol category, but these differences did not reach statistical significance.

In Table 2 we compared the levels of total cholesterol and triglycerides between the baseline and the follow-up examinations. A sample of 285 firefighters who had no missing data was used for the prospective comparisons of total cholesterol. There were no statistically significant differences in age, BMI, and systolic or diastolic blood pressure between firefighters who were excluded because of missing values on total cholesterol and firefighters who were included in the prospective analyses. The majority of the firefighters were found to have either borderline-high (36%) or high (33%) cholesterol levels at baseline. In addition, a considerable proportion of the study population (13%) had persistently high total cholesterol values over time (baseline and follow-up examinations); however, there was a

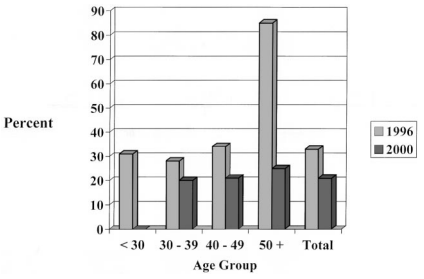

Fig. 2. The distribution of high total cholesterol (≥240 mg/dL) by age group in the study population at baseline and follow-up examinations. The light bars represent the population distribution in 1996, and the dark bars represent the distribution in 2000.

statistically significant shift of total cholesterol levels to lower values after 4 years of follow-up. The distribution of high total cholesterol by age group and examination (baseline and follow-up) is shown in Fig. 2.

In addition, we compared the levels of triglycerides over time in 168 firefighters who had complete data on both examinations. There were no statistically significant differences in age, BMI, and systolic or diastolic blood pressure when we compared firefighters with complete data on serum triglycerides with those with any missing data. Unlike the declining pattern of total cholesterol levels, the values of serum triglycerides increased over time, as shown in Table 2. A similar pattern of increasing values over time was observed for BMI as well. At baseline, 34% of firefighters had a BMI ≥ 30 kg/m^2, whereas at follow-up, the proportion of obese firefighters increased to 40% ($P = 0.008$).

The levels of LDL and HDL cholesterol for those with complete data at the follow-up examination are presented in Table 3. Values for LDL and HDL for the baseline examination were not obtained. The mean HDL cholesterol was 47 mg/dL (range, 26–96 mg/dL), and a considerable percentage of firefighters (26%) were found to be in the lowest HDL cholesterol category (HDL < 40 mg/dL). The mean LDL cholesterol value was 133 mg/dL (range, 37–236 mg/dL). A considerable proportion of firefighters (17%) was found to have high or very high LDL cholesterol values (≥160 mg/dL). In addition, there was an increase in the proportion of firefighters with low HDL and high LDL cholesterol levels with advancing age.

TABLE 3.
Distribution of HDL and LDL Cholesterol Levels in Hazardous-Materials Firefighters

	n	Follow-Up Examination in 2000
HDL cholesterol (mg/dL)*	285	
Mean (±SD)		47 (±12)
<40 (% low)		25.6
40–59 (% intermediate)		60.4
≥60 (% high)		14.0
HDL cholesterol <40 mg/dL by age category	285	% (*n*)
<30 years old		1.1 (3)
30–39 years old		6.3 (18)
40–49 years old		11.9 (34)
≥50 years old		6.3 (19)
Total		25.6 (73)
LDL cholesterol (mg/dL)*	275	
Mean (±SD)		133 (±31)
<100 (% optimal)		12.0
100–129 (% above optimal)		36.0
130–159 (% borderline high)		34.2
160–189 (% high)		13.8
≥190 (% very high)		4.0
LDL cholesterol ≥ 160 mg/dL by age category	275	% (*n*)
<30 years old		0 (0)
30–39 years old		5.4 (15)
40–49 years old		8.7 (24)
≥50 years old		3.6 (10)
Total		17.8 (49)

* HDL and LDL values were not available at the baseline examination in 1996–1997.

In Table 4 we present information on lipid-lowering medication use at the baseline and follow-up examinations. Decisions on treatment were made neither by the physicians in our research team nor by the occupational physicians performing the medical surveillance examinations. The lipid-lowering medications were prescribed by the firefighters' primary care physicians according to their own medical care practices. A significantly higher number of firefighters were taking lipid-lowering medications at follow-up compared with baseline ($P < 0.0001$). It is also notable that only a small proportion of firefighters with persistently high cholesterol levels at both examinations was taking medications at follow-up (14%). Among 49 firefighters with high or very high LDL cholesterol levels (≥160 mg/dL), only five (10%) were taking medications at follow-up. In addition, among firefighters with high cholesterol values ($n = 61$), only nine (15%) were taking lipid-lowering medications at follow-up, and among firefighters with high triglycerides ($n = 59$), only 14 (24%) were on medications at follow-up. Finally, among firefighters with high total cholesterol, high triglycerides, and high LDL cholesterol ($n = 9$), only two (22%) were found to be taking lipid-lowering medications at follow-up.

Discussion

The results of this investigation show that the majority of the hazardous-materials firefighters had abnormal levels of total cholesterol at the

TABLE 4
Lipid-Lowering Medication Use by Hazardous-Materials Firefighters at the Baseline and Follow-Up Examinations

	Baseline Examination (1996–1997) Percent (*n*)	Follow-up Examination, 2000 Percent (*n*)
Firefighters on lipid-lowering medications ($n = 285$)	2.8 (8)	12.3 (35)
Firefighters with		
Total cholesterol < 240 mg/dL	1.1 (2)	11.6 (26)
Total cholesterol ≥ 240 mg/dL	6.3 (6)	14.7 (9)
Firefighters with*		
HDL cholesterol ≥ 40 mg/dL	—	10.8 (12)
HDL cholesterol < 40 mg/dL	—	16.4 (23)
Firefighters with*		
LDL cholesterol < 160 mg/dL	—	12.7 (30)
LDL cholesterol ≥ 160 mg/dL	—	10.2 (5)
Firefighters on lipid-lowering medications ($n = 168$)	1.8 (3)	13.7 (23)
Firefighters with		
Serum triglycerides < 200 mg/dL	0	8.3 (9)
Serum triglycerides ≥ 200 mg/dL	6.5 (3)	23.7 (14)

* HDL and LDL values were not available at the baseline examination.

baseline as well as the follow-up examination. The mean total cholesterol and distribution of values, however, were found to be significantly lower after 4 years of follow-up. On the contrary, serum triglycerides had increased significantly at follow-up. This result was likely due to a parallel increase in BMI. Finally, despite an increase in the proportion of firefighters with high cholesterol who were taking medications at follow-up, the majority of firefighters for whom drug treatment was indicated based on their lipid profile (78%) were not on lipid-lowering medications.

Previous studies have shown that the levels of total cholesterol among the general population have been declining during the past decade.[17,18] This declining pattern has been attributed to a greater awareness among the general population of the adverse effects of high cholesterol, changes in diet, and lipid-lowering medication use.[19–21] We observed a similar pattern among firefighters. In addition, even after excluding firefighters who were taking medications, the mean cholesterol in the study population showed a significant decrease at follow-up compared with baseline (220 mg/dL vs 214 mg/dL, $P = 0.002$), suggesting that other health behaviors also contributed to this decline. Nevertheless, a considerable number of firefighters with abnormal lipid profiles were not taking medications even after 4 years of repeated screening.

Serum triglycerides, unlike total cholesterol, were found to be significantly increased at follow-up. The increase in triglycerides was accompanied by significant increases in BMI among the firefighters, supporting the validity of this finding. Higher levels of serum triglycerides are associated with a higher BMI.[22]

Firefighters were more likely to be on lipid-lowering medications at the follow-up compared with the baseline examination (3% vs 12%, $P < 0.0001$). This is not surprising, because the firefighters were being notified of their cholesterol levels and other laboratory results at every examination, and they were encouraged to consult their primary care physicians and take appropriate action for any abnormal values. The apparent significant increase in medication use after 4 years of follow-up could be attributed, in part, to the surveillance program itself.

Other significant findings of our study include the distributions of HDL and LDL cholesterol values among the firefighters. We found very high proportions of firefighters with abnormal HDL and LDL cholesterol levels, and the majority of these individuals had not been prescribed medications. Low HDL cholesterol is an independent risk factor for cardiovascular disease and is also known to be a modifiable risk factor.[23,24] Cardiovascular mortality is the most common cause of on-duty mortality in firefighters, being responsible for ~45% of on-duty deaths.[25] The results of our study suggest that comprehensive preventive programs are needed to address several modifiable cardiovascular disease risk factors among firefighters, including abnormal values of total, LDL, and HDL cholesterol. In addition, serum triglycerides and obesity showed an increasing pattern, which also require intervention. Recommended regular exercise would be an appropriate approach that could favorably affect several of these problems, including obesity, serum triglycerides, and HDL and total cholesterol.[26]

There are several limitations worth noting in our study. The annual examinations and data collection processes were conducted at three different hospitals for six regional hazardous-materials teams. There were no significant differences, however, in the mean total cholesterol values among the three hospitals ($P = 0.20$). Furthermore, the follow-up comparisons for paired observations were performed on firefighters who had complete data on both examinations. Another possible concern relates to the use of random (nonfasting) blood tests to measure the lipid profile of the participants. Owing to the fact that the annual surveillance examinations were performed during working hours, firefighters were not able to provide fasting blood samples. Previous studies have shown, however, that there is little difference in total cholesterol

or HDL cholesterol when comparing fasting with casual values.[1] Although triglycerides are significantly influenced by fasting, and individual treatment plans cannot be based on casual measurements, population comparisons are useful to elucidate temporal trends. Possible bias because of the use of nonfasting values would most likely be random (nondifferential) and therefore, would bias the results toward the null hypothesis, ie, of no significant change of triglyceride levels over time.

In conclusion, we observed a significant decrease in total cholesterol levels among firefighters after 4 years of follow-up, partly attributable to increased lipid-lowering medication use. Serum triglycerides and BMI were increased at follow-up and require further investigation and monitoring. HDL and LDL cholesterol were found to be abnormal for a considerable proportion of firefighters, and only a small number of these cases were receiving lipid-lowering medications. Occupational and primary care physicians need to be aware of these findings because coronary heart disease continues to account for ~45% of on-duty deaths[25] and for ~36% of lifetime mortality in firefighters.[27–34] Therefore, firefighters should be managed aggressively according to current evidence-based medical standards. Certain administrative measures, such as the encouragement of exercise programs, delivery of appropriate diet schedules, and cardiovascular disease risk factor screening programs in fire departments, would also help improve the current risk factor profile of firefighters and prevent adverse health outcomes.

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