Efficacy of an Intervention to Promote Use of Hearing Protection Devices by Firefighters

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Cooperation and assistance in this project were provided by the City of Columbia Fire Department; City of Columbia/Boone County Health Department; University of Missouri Hospital and Clinics, Department of Audiology; and Ray Morrison, Safety Consultant at the University of Missouri at the time of the study. Partial financial support was provided by Biomedical Research Support Grant DHHS-5-S07-RR005387-23.

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Synopsis

Numerous cases of hearing loss consistent with noise-induced damage were noted among firefighters in the city of Columbia, MO. A survey of firefighting vehicles in operation showed that the firefighters were exposed to excessive noise levels and put at risk for noise-induced hearing loss (NIHL). Audiologic evaluation showed that 36 percent of the firefighters had moderate or severe hearing loss (a threshold of 40 decibels (dB) or more at 3,000, 4,000, or 6,000 hertz (Hz) in either ear).

An educational program on NIHL was then carried out to increase the use of hearing protection devices (HPDs) by firefighters, followed by an evaluation of the intervention. The educational intervention successfully increased knowledge of NIHL, positive attitudes toward HPDs, and resulted in more frequent use of HPDs. After the intervention, 85 percent of firefighters regularly used HPDs compared with 20 percent before the intervention. Recommendations are made for fire departments to reduce the risk of NIHL.

NOISE-INDUCED HEARING LOSS (NIHL) ranks among the most important work-related conditions because of its high prevalence, the disability it creates, and the potential for preventing it (*1*). The occupational risk of NIHL in industries that expose workers to continuous high levels of noise is well-established (*2*). Yet there is no effective treatment for permanent hearing loss resulting from excessive exposure to noise. Prevention, therefore, is the only effective means of reducing the impact of the problem (*2*).

Federal law mandates hearing conservation programs in occupational settings where time-weighted noise levels exceed limits set by the Occupational Safety and Health Adminstration (OSHA) (*3*). For example, exposure longer than 8 hours daily exceeds the OSHA limit for the lowest noise level, 90 decibels (dB); the OSHA limit for 110 dB of sound is exceeded when exposure surpasses one-half hour per day.

At present, OSHA does not mandate hearing conservation programs in fire departments (*3*). Exposure to noise among firefighters varies with the number and length of emergency responses. The noise exposures reported in two National Institute for Occupational Safety and Health (NIOSH) studies of fire departments (*4,5*), although sufficient to cause hearing loss, did not exceed the OSHA limits. Nevertheless, several authors have concluded that noise exposure of firefighters results in an increased risk of hearing loss and have recommended that fire departments take preventive measures (*4–7*).

We physicians responsible for employee health evaluations for the city of Columbia, MO, at the time of this study, noted many cases of high frequency hearing loss (HFHL) consistent with NIHL during reviews of audiograms conducted as part of routine physical evaluations of fire department employees in 1985. As a result, this study was undertaken (*a*) to determine if a hearing conservation program was warranted for firefighters in the Columbia Fire Department, and if so, (*b*) to design an educational intervention to increase the use of

hearing protection devices (HPDs) by firefighters and to evaluate the effect of this intervention.

Methods

Sample. We conducted the study in 1986 with the cooperation of the city fire department and health department of Columbia, MO, and the participation of all 94 of the active full-time city firefighters. The mean age of the city firefighters was 35 years, and their average length of employment in the department was 11 years.

Assessment of need for a hearing conservation program. A University of Missouri-Columbia safety consultant conducted a noise survey of fire department operating equipment using a Quest dosimeter. He tested six vehicles during simulated operations or in stationary positions. Sound levels were measured from one to six positions on the vehicle (for example, the driver or jump seat). Sources of noise measured included engines, air horns, sirens, radio transmissions, and pumps.

Audiologists from the University of Missouri-Columbia did pure-tone audiograms by OSHA standards on 89 of the 94 firefighters to confirm firefighters' hearing loss. Five firefighters did not receive audiograms due to scheduling problems. Thresholds, recorded in dBs, are reported in this paper for only three test frequencies considered to be especially sensitive to NIHL (*2*)—3,000, 4,000, and 6,000 Hz.

Both ears were tested. The hearing loss category for each firefighter was determined by the highest (worst) threshold from either ear at 3,000, 4,000, and 6,000 Hz. A threshold below 20 dB represented normal hearing; a threshold between 20 and 40 dB indicated a mild hearing loss; a threshold between 40 and 60 dB, a moderate hearing loss; and a threshold over 60 dB, a severe hearing loss.

To determine the extent to which noise exposure that was not fire service related may have caused hearing loss, the firefighters completed a questionnaire (the noise exposure questionnaire). The questionnaire asked about military service; exposure to gunfire in the military; participation in recreational activities that involve exposure to noise such as hunting, motorcycling, and use of power tools; history of occupational noise exposure; and previous use of hearing protection devices.

Intervention. The intervention designed to promote the use of HPDs by firefighters was delivered in two phases in a 3-month period. Phase I was an intensive educational program on NIHL and its prevention over the course of 1 month (Hearing Conservation Month). Phase 2 included a 2-month trial with three choices of HPDs (muffs, roll-up plugs, or premolded plugs) for the firefighters' use (the Trial Use Period).

Hearing Conservation Month consisted of an intensive education program designed to promote the wearing of HPDs. It was presented to the 94 full-time firefighters during February 1986. Each week participants received a 1-page patient education handout on an aspect of NIHL. The handouts, which we prepared and distributed in the following sequence, emphasized these major points: (*a*) noise can damage hearing, (*b*) excess noise exposure is common, (*c*) hearing loss creates disabilities, and (*d*) hearing loss can be prevented. Additional educational activities that coincided with the weekly handouts included posters, a videotape on NIHL produced by the E.A.R. Company, a 10-page booklet, and a videotaped interview in which several Columbia firefighters talked about the impact of hearing loss on their lives. During the fourth week there was a lecture and a question and answer session held at the training station.

At the end of Hearing Conservation Month, we provided firefighters with three types of personal HPDs for their use during emergency responses for a 2-month trial: a roll-up expandable foam earplug, a premolded earplug, and ear muffs (*A*). Although fire department administrators were supportive of the intervention, they did not direct the firefighters to use the HPDs, and there was no policy on the use of HPDs in effect during the Trial Use Period.

Outcomes and data analyses. To measure firefighters' baseline knowledge of and attitudes toward NIHL before the intervention, a questionnaire was distributed by mail (the preintervention questionnaire) to all firefighters in the Columbia Fire Department on the first day of Hearing Conservation Month. The questionnaire contained 17 true-false items that measured knowledge of NIHL and fire attitudinal statements about NIHL and HPDs to which firefighters responded on a 1 to 5 point scale (strongly agree to strongly disagree).

The firefighters completed an identical questionnaire (the postintervention questionnaire) on the last day of Hearing Conservation Month. The firefighters reported frequency of HPD use before the intervention in the noise exposure questionnaire. The preintervention questionnaire lacked code numbers to avoid any impression that the

responses could have negative repercussions on the firefighters and therefore be biased; thus it was not possible to distribute the second questionnaire to nonresponders. The noise exposure questionnaire and postintervention questionnaire were distributed at required training meetings. At the end of the 2-month Trial Use Period, each firefighter was interviewed by a safety consultant experienced with problems in the use of a HPD. He discussed problems that the firefighters had using the HPDs and determined the frequency of use over the Trial Use Period.

The percentage of questions about NIHL answered correctly was calculated for each firefighter responding to the preintervention questionnaire and each firefighter responding to the postintervention questionnaire. The mean percent correct score on the preintervention questionnaire was compared with that on the postintervention questionnaire by *t*-test to determine if the educational intervention improved knowledge of NIHL. A paired-score analysis could not be used because the questionnaires had been distributed anonymously and without code numbers to assure firefighters that the information reported would not affect their employment status.

Chi-square tests were used to compare the percentage of correct and incorrect responses to three pre- and postintervention questionnaire items measuring knowledge of NIHL. To assess the effect of the educational intervention on NIHL-related attitudes, chi-square tests were used to compare the percent of agreement (strongly agree or agree) and disagreement (neutral or disagree or strongly disagree) expressed on five pre- and postintervention questions measuring NIHL-related attitudes.

Firefighters were classified as participants in a noisy recreational activity at three levels: none, one to three activities per month, and four or more activities per month. Level of participation in these activities was compared with presence of hearing loss by chi-square analysis.

Simple regression analyses were done to assess the relationship of firefighter's age and years in firefighting to the degree of hearing loss experienced in this sample of firefighters. A multiple regression analysis was done to assess the relative contribution of age and years in service to the degree of hearing loss.

Results of assessment of need for hearing conservation program. Sound levels recorded ranged from a low of 72 dB from idling engine noise measured from a passenger position on Reserve Engine 1 to a high of 110 dB or more from a siren measured at the front of Engine 4. Of a total of 63 measurements, 45 measurements between 90 and 110 dB were recorded. Four of the 65 exceeded 110 dB. At least 49 measurements (or 78 percent of the measurements) taken from each kind of vehicle in a variety of positions exceeded 89 dB.

Table 1. Hearing loss of Columbia, MO, firefighters as shown by frequency distribution of thresholds from audiograms

Threshold[1]	*Number*[2]	*Percent*
Normal (less than 20 db)	27	30
Mild loss (20 to 39 db)	30	34
Moderate loss (40 to 59 db)	20	22
Severe loss (greater than 59 db)	12	14
Total	89	100.0

[1]Highest threshold from either ear at 3,000, 4,000, or 6,000 Hz.
[2] Five of the total of 94 firefighters were not tested due to scheduling problems.

Table 2. Hearing loss as a function of participation in noisy recreational activities by Columbia, MO, firefighters

	Number of noisy activities					
	0		*1–3*		*4 or more*	
Hearing loss	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
None or mild	13	81	29	62	15	58
Moderate or severe	3	19	18	38	11	42
Total	16	100	47	100	26	100

NOTE: $\chi^2 = 2.62$, $df = 2$, $P = .27$.

Measurement of hearing loss. Table 1 shows the results of the audiograms. Twenty-two percent, or 20 of the 89 firefighters, had evidence of moderate HFHL, and 14 percent (12 firefighters) had severe HFHL, consistent with NIHL.

Hearing loss from sources other than fire service. Table 2 displays the percentage of firefighters according to participation in noisy recreational activities who showed moderate or severe hearing loss. There is a trend suggesting a relationship between the number of noisy activities and amount of hearing loss; however, the association is not statistically significant ($\chi^2 = 2.62$, $P = .27$).

Table 3 displays the percentage of firefighters with and without military service who showed moderate or severe hearing loss on their 1985 audiograms. Firefighters with military service were more likely to have moderate or severe hearing loss than firefighters who had never served in the

Table 3. Hearing loss as a function of military service

Hearing loss	Military service		No military service	
	Number	Percent	Number	Percent
None or mild	18	50	39	74
Moderate or severe	18	50	14	26
Total	36	100	53	100

NOTE: $\chi^2 = 4.21$, $df = 1$, $P = .04$

Table 4. Predictors of degree of firefighter hearing loss

Category	R^2	df	F	P
Simple regressions				
Years in fire service	.08	1	7.98	.006
Firefighter's age	.10	1	9.70	.003
Multiple regression				
Model[1]	.10	2	4.85	.01
Years in fire service	...	1	1.15	.28
Age	...	1	.29	.59

[1]Model = strength of the relationship between the target variable (HFHL) and the predictor variables operating jointly (age, years in service).

NOTE: R^2 = coefficient of determination; df = degree of freedom; F = F statistic; P = probability value.

military. There was no association of military exposure to gunfire and prevalence of hearing loss. Most of the firefighters had worked only in the fire service during their careers. Therefore, noise exposure in other jobs was not a significant factor.

Results of regression analysis (table 4) showed a strong relationship between years of service in the fire department and level of HFHL ($F = 7.98$, $P < .01$) and a strong relationship between firefighter's age and level of HFHL ($F = 9.70$, $P < .01$). However, when age was entered into the multiple regression equation simultaneously with years of service, no statistically significant relationship of either years of service or age was found with the level of HFHL. The degree of multicollinearity between the two independent variables (a correlation coefficient of .85 was found between age and years of service) precluded an assessment of the independent contribution of these two variables to HFHL.

Results of the Intervention

Knowledge of NIHL. Knowledge scores after the educational intervention were higher than those measured before the intervention. The mean percent correct score on 17 knowledge questions was 72 percent on the preintervention questionnaire and 86 percent on the postintervention questionnaire. The two means were significantly different ($t = 7.25$, $P < .01$).

Table 5 shows the percentage of respondents who correctly answered each of three important questions from the preintervention and postintervention questionnaires designed to assess knowledge, treatment, and prevention of NIHL. For each item, the percentage of firefighters responding correctly was significantly higher on the postintervention questionnaire. More respondents knew that hearing aids do not improve NIHL, that surgery does not correct NIHL, and that HPDs prevent NIHL. The results of answers to these three questions are presented separately because of the assumed importance of this knowledge in motivating behavior change among these firefighters.

Attitudes toward HPDs. Table 6 displays the percentage of respondents to the preintervention and postintervention questionnaires who agreed with each of the five attitudinal statements about HPDs. The postintervention 1 percent who believed that HPD use is dangerous for firefighters was significantly lower than the preintervention 16 percent ($P = .01$). The 82 percent who would wear HPDs if they were available was significantly higher than the preintervention 62 percent ($P = .02$). There were no significant before-and-after differences in the percentages of agreement on the three other items.

Changes in use of HPDs. Only 18 (20 percent) of the 91 firefighters who responded to the noise exposure questionnaire had ever used HPDs at work. Three firefighters did not complete this questionnaire. At the end of the Trial Use Period 80 of 94 (85 percent) firefighters stated that they had worn an HPD during every emergency response during the preceding 2 months.

Discussion

Efforts to reduce the risk of hearing loss have focused on such occupations as mining, heavy industry, and transportation where workers are exposed to continuous high levels of noise. Recently, several studies have addressed the risk of NIHL in firefighters (*3–6*) whose exposure during emergency response to noise from equipment such as engines, air horns, sirens, radio transmissions, and pumps is intermittent. Surveys of two fire departments by NIOSH established that firefighters were exposed to excess levels of noise (*5,6*). More

significantly, other studies have documented an excess of HFHL consistent with NIHL in firefighters, despite the intermittent nature of exposure to high noise levels (*3–6*).

Prevention of NIHL can be accomplished through three strategies: reduction of noise exposure, rotation of workers exposed to noise, and use of a personal HPD. For example, engineering innovations in firefighting equipment such as insulated cabs, front-bumper positioning of sirens, and increased noise protection for crew members riding in the jump seat can decrease the amount of noise to which firefighters are exposed during emergency responses. Fire departments can immediately reduce the amount of noise to which their employees are exposed by purchasing new equipment that has incorporated these engineering modifications.

However, equipment changes are expensive and do not completely eliminate the risk. A second strategy, rotation of workers between noisy and quiet work assignments, results in a lower level of risk, but the risk is then extended to more workers. This approach may not be practical in fire departments where exposure to loud noise is often unpredictable. The third strategy, use of personal hearing protective devices, often reduces exposure by 20 to 30 dBs and is inexpensive. Consequently, use of HPDs has been recommended as a part of hearing conservation programs (*2,4,5*) in selected fire departments.

Since time-weighted averages were not computed in this study, it is not known whether the noise levels experienced by Columbia firefighters exceed OSHA levels and whether a hearing conservation program would thus be mandatory under Federal law. Nevertheless, the results of this study showed that the Columbia firefighters are probably exposed to noise levels high enough to put them at risk for NIHL. A high percentage of noise measurements exceeded 89 dB. In addition, several readings of more than 110 dB were measured in the noise survey, the upper range of measurement on the dosimeter used in the study. Exposure levels recorded in the Columbia noise survey are consistent with those reported in other studies of fire department noise levels (*4–6*). More important, HFHL consistent with auditory damage due to noise exposure exists in this sample of firefighters. Exposure to noise in the military and in recreational activities may account for some of the hearing loss documented among these firefighters, but neither of these variables were as strongly associated with hearing loss as age and years in firefighting.

It is unlikely that hearing loss due to aging (presbycusis) is the only reason for the findings of this study, even though the independent contribution of age and years in the fire service could not be assessed in this sample. The hearing loss found in the sample of Columbia firefighters is consistent with findings from other studies and surveys and is probably excessive (*6–10*). Studies of the Houston and Los Angeles fire departments have shown levels of hearing loss among firefighters that statistically are significantly different from those of an age-matched control group from the National Health Survey (*4,7*).

Results of the evaluation of the educational intervention showed that (*a*) knowledge of NIHL among firefighters was increased, particularly that it is untreatable but preventable, and (*b*) attitudes toward prevention of NIHL could be made more favorable. The proportion of firefighters who believed HPDs were dangerous decreased, and willingness to use HPDs increased. Most importantly, exposure to the intervention brought about a dramatic change in firefighters' behavior. Before the intervention, only 20 percent of the firefighters were using hearing protection at any time. Subse-

Table 5. Columbia, MO, firefighters' knowledge about noise-induced hearing loss in responses to pre- and postintervention questionnaires[1]

Item	Preintervention (N = 56) Percent correct	Postintervention (N = 85) Percent correct	P[2]
Hearing aids correct NIHL (false)	30	86	<.001
Surgery corrects NIHL (false)	70	95	<.001
Hearing protective devices prevent NIHL (true)	61	97	<.001

[1]Questionnaires were returned by 56 and 85 of the 94 firefighters respectively.
[2]By chi-square, *df* = 1.

Table 6. Columbia, MO, firefighters' attitudes toward hearing protection devices on responses to questionnaires

Item	Preintervention (N = 56) Percent agree	Postintervention (N = 85) Percent agree	P[1]
HPDs are not practical	17	7	.13
HPD use requires too much time	7	14	.34
HPD use is dangerous	16	1	.01
Would use HPDs if available	62	82	.02
Prevention of NIHL is a low priority	6	4	.82

[1]By chi-square, *df* = 1.

quently, 85 percent were using ear muffs, or another kind of protective device regularly.

Exposure to the educational intervention did not significantly alter the perceived practicality of HPDs, the priority put on preventing NIHL, and perceptions of the time that it takes to use HPDs. However, only a few respondents gave a low priority to preventing NIHL on the preintervention questionnaire (6 percent).

While not statistically significant, the percentage of respondents who thought HPD use took too much time increased from the preintervention (7 percent) to the postintervention questionnaire (14 percent). At the time the postintervention questionnaire was administered, the firefighters had been instructed in the proper use of the roll-up type protective devices, which required at least 60 seconds for preparation and insertion, and they had not yet been through the trial period when they would be allowed to choose ear muffs that are much more quickly applied. The failure of the intervention to decrease significantly the percentage of firefighters who believed the use of HPDs was impractical may reflect this initial experience with the more time-consuming roll-up plug.

Most firefighters preferred the ear muffs over the plugs. The roll-up type plugs took too much time to insert after the alarm sounded. Most firefighters did not like to wear the plugs continuously at the station because of the mild discomfort they caused. The premolded earplug could be inserted much more quickly but resulted in more irritation to the ear canal. In contrast, the ear muffs were quickly applied and were not irritating.

Two problems were noted with ear muff use. The E.A.R. model 3000 ear muffs would not fit below one type of firefighter helmet. However, the smaller muff (E.A.R. model 1000) did not pose this problem. Some, especially the fire engineers, found that radio communications were impaired with the use of the muff, particularly when the engineer at the scene of the fire was attempting to maintain communication with other personnel while operating the pump panel. A few firefighters with significant HFHL found communications to be consistently impaired with use of the muffs, although most reported improved understanding of radio messages during emergency responses when they wore the muffs.

A response rate of only 56 of the firefighters (tables 5 and 6) was obtained on the pretest, because no efforts were made to remind nonrespondents to return questionnaires. It is not known how representative this subsample of nonrespondents is of the entire group of Columbia firefighters. If nonrespondents tended to know less and care less about NIHL—a plausible assumption to make, based on their lack of motivation to respond to the questionnaire—their omission from the preintervention data may have artificially raised preintervention knowledge scores. This would lead to an underestimation of the effect of the intervention. Despite the potential bias, the educational intervention was found to increase significantly knowledge of NIHL and improve attitudes about the use of HPDs.

Recommendations

The following recommendations were made to the fire department:

- All new fire personnel should be educated about NIHL during orientation or training sessions.
- The fire department should provide all fire personnel with a personal HPD. Ear muffs are the preferred device because they are easy to use, do not cause irritation, and reduce noise effectively. The muff should fit under the helmets. Ear plugs assigned for hearing protection are acceptable alternatives for the few firefighters who prefer them.
- The device should be applied as soon as is practical after the alarm sounds. It should be worn until arrival at the fire scene, since most noise exposure occurs from air horns and sirens. Removal at the scene is recommended to avoid any interference with communication from the device and to avoid burns should the device overheat.
- The department should provide communication devices containing built-in microphones and receivers to be used by the fire engineer. In addition, other personnel with hearing loss so significant that the use of standard protective devices results in communication problems should be furnished with communication devices.
- Use of the HPD should be mandatory; policy implementation and compliance should be ensured, for example, by observations by the shift commanders.

Conclusion

In summary, this educational intervention successfully improved knowledge of NIHL and attitudes toward its prevention. In addition, it successfully changed behavior necessary to prevent a serious occupation-related disability. After this

study was concluded, the Columbia Fire Department provided appropriate HPDs to all personnel and carried out a policy requiring their use. Six months after the study was completed, shift commanders were asked to observe HPD use during emergency responses for 1 week. They reported that most of the firefighters in the Columbia City Fire Department were regularly using HPDs.

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Equipment

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Awareness and Use of Hepatitis B Vaccine Among Homosexual Male Clients of a Boston Community Health Center

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The study was supported by a grant from Merck Sharp & Dohme, Inc.

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Synopsis

Factors associated with awareness and acceptance of hepatitis B vaccine were identified among 150 homosexual male clients of a Boston community health center. Five percent of the subjects were unaware of hepatitis B and 25 percent had a history of hepatitis. Among the remaining 106 men, 68 percent were aware of the vaccine, and 25 percent of these had been vaccinated. Awareness of vaccine was associated with education beyond the baccalaureate level. Factors associated with vaccination included at least one prior visit to the health center, having health insurance, and extent of knowledge of the effects of hepatitis B. Among those not vaccinated, 68 percent would like to be but were deterred by the perceived high cost of the vaccine. The predominant reason given by the 31 percent who have decided not to be vaccinated was the perception that they were not at risk because of monogamous sexual relationships, or "safer" sexual practices. Strategies for maximizing vaccine use among homosexually active men should focus on increasing both awareness of the vaccine and appropriate perceptions of risk.