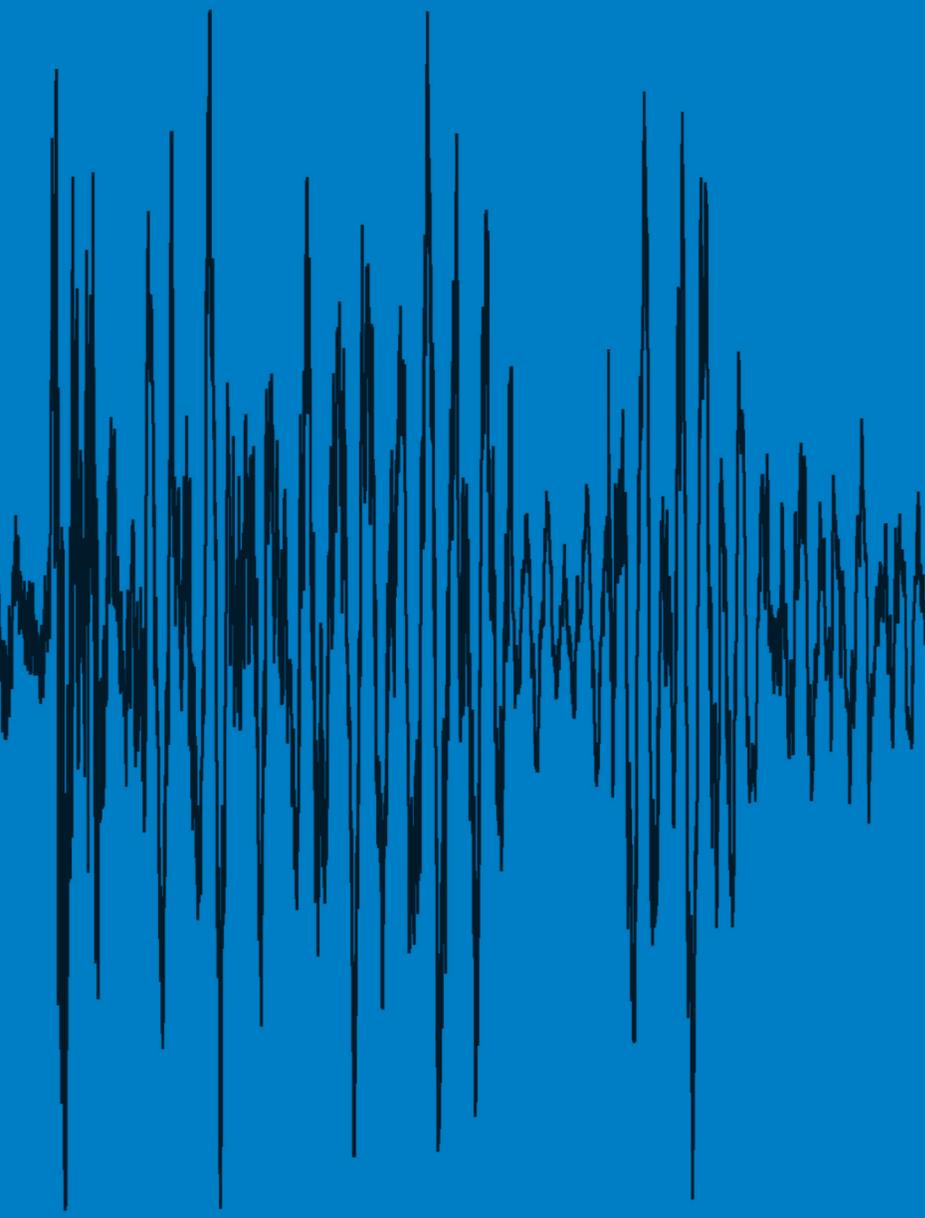


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# Hearing loss prevention for carpenters: Part 2 – Demonstration projects using individualized and group training

Mark R. Stephenson, Peter B. Shaw, Carol Merry Stephenson<sup>1</sup>, Pamela S. Graydon

National Institute for Occupational Safety and Health, Division of Applied Research and Technology, 4676 Columbia Parkway, Cincinnati, and <sup>1</sup>National Institute for Occupational Safety and Health, Education and Information Division, 4676 Columbia Parkway, Cincinnati, OH 45226-1998, USA

## Abstract

Two demonstration projects were conducted to evaluate the effectiveness of a comprehensive training program for carpenters. This training was paired with audiometry and counseling and a survey of attitudes and beliefs in hearing loss prevention. All participants received hearing tests, multimedia instruction on occupational noise exposure/hearing loss, and instruction and practice in using a diverse selection of hearing protection devices (HPDs). A total of 103 apprentice carpenters participated in the Year 1 training, were given a large supply of these HPDs, and instructions on how to get additional free supplies if they ran out during the 1-year interval between initial and follow-up training. Forty-two participants responded to the survey a second time a year later and completed the Year 2 training. Significant test-retest differences were found between the pre-training and the post-training survey scores. Both forms of instruction (individual versus group) produced equivalent outcomes. The results indicated that training was able to bring all apprentice participants up to the same desired level with regard to attitudes, beliefs, and behavioral intentions to use hearing protection properly. It was concluded that the health communication models used to develop the educational and training materials for this effort were extremely effective.

*Keywords:* Hearing conservation, hearing protectors, training

## Introduction

In response to a request from the United Brotherhood of Carpenters and Joiners of North America (UBC), in 2000, the National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation (HHE) to assess occupational hearing loss among carpenters. The results indicated that many carpentry tasks exposed workers to levels in excess of 85 dBA.<sup>[1]</sup> The corresponding audiometric tests demonstrated mean hearing threshold levels consistent with time-weighted average (TWA) exposures in excess of 95 dBA. It was concluded that by age 25, the average carpenter had “50-year-old ears,” and that by age 50, two out of three carpenters were past the point of needing a hearing aid.<sup>[2]</sup>

As a result of the NIOSH HHE, the UBC asked NIOSH to develop a hearing loss prevention program (HLPP) that could be integrated into their existing health and safety training and administered at UBC Joint Apprenticeship Training Centers (JATCs), which were located across the United States. The training was designed to fill a 45–60-min time block. It was to include audiometry, education/training, and dispensing hearing protection devices (HPDs). Considerable effort went into the development of the educational and training materials, the selection of HPDs, and the development of a survey tool. The survey tool was used to query carpenters’ attitudes, beliefs, and behavioral intentions associated with hearing loss prevention behaviors – particularly those associated with the use of HPDs. Details on the theoretical basis for the educational and training materials and the survey development and content are discussed in Part I, which is published in a separate manuscript of this issue.<sup>[3]</sup> Briefly, Part I addresses an eclectic application of the Health Beliefs and Health Promotion Models, the Theory of Reasoned Action, and the Transtheoretical Model to develop the educational and training materials used in this study. The present paper describes the results of two demonstration projects designed to evaluate how well these educational and training materials were able to positively influence carpenters’ attitudes,

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beliefs, and behavioral intentions to use HPDs. These efforts consisted of identical training materials presented at two Midwestern carpenter training centers. At one center, training was individually presented, and at the other center, training was presented in a traditional classroom environment.

## Methods

### Subjects

The NIOSH Human Subject Review board approved the procedures used in this study under protocol HSRB-01-DART-08. All participants were volunteers enrolled in the first, second, or third year of a 4-year apprentice training program sponsored by the UBC. Approximately half of the participants were located at a training facility in Indianapolis, IN, and half were located at a training facility in the Cincinnati, OH, metropolitan area (Monroe, OH). These sites were chosen in part because the training center leadership provided extensive support regarding access to apprentices, in part because of the proximity to NIOSH researchers who would be routinely conducting on-site activities, and in part because the training centers provided a broad spectrum of training and work tasks associated with carpentry. It was also unlikely that apprentices from the two different facilities would interact, potentially contaminating the study design. Every first and second year apprentice at each facility had an equal opportunity to enroll in the study. No one was declined participation. Subjects were asked to fill out a survey of their attitudes and beliefs about hearing loss prevention four times during the course of this effort: prior to and after training in both the initial year and prior to and after training 1 year later. Participants were also asked to take a hearing test at the inception of the study, and again 1 year later. Details of the survey and audiometry are discussed below.

### Hypotheses

This demonstration project postulated the following three hypotheses:

1. One-on-one/pair training is more effective than classroom group training.
2. Using a theory-based health communication and health promotion approach, a hearing loss prevention training program can be developed that will significantly affect trainees' attitudes, beliefs, and behavioral intentions to protect their hearing and to wear hearing protection appropriately.
3. Refresher training is effective in maintaining desired levels of attitudes, beliefs, and behavioral intentions.

### Targeted constructs

The educational and training materials used in this study employed sharply focused messages to carefully target specific constructs shown to be relevant to apprentice carpenters' decisions to protect their hearing from hazardous noise. Both the training and the survey tool addressed the

following constructs: (1) perceived susceptibility to hearing loss, (2) perceived severity of the consequences of hearing loss, (3) perceived benefits of preventive action, primarily seek hearing tests to monitor one's own hearing and wear hearing protection when and where appropriate, (4) perceived barriers to preventive actions, (5) self-efficacy to select, fit, and wear appropriate hearing protection, (6) social norms within ones' work settings associated with hearing loss prevention, and (7) stated behavioral intentions to engage in recommended actions. By incorporating these constructs into the hearing conservation training, the authors hypothesized that it would be possible to positively influence the attitudes, beliefs, and behavioral intentions associated with hearing protector use among carpenters. To accomplish this, NIOSH developed a model training program as well as a survey tool designed to evaluate program effectiveness.<sup>[3]</sup> NIOSH also attempted to conduct behavioral observations of hearing protector use, but, as is discussed below, this did not prove to be logistically possible.

### 28-item survey

The Office of Management and Budget approved the use of the survey with study participants. Details regarding the validity and reliability of the survey questions, form A and form B equivalence, the general procedures used to develop the survey, and the theoretical underpinnings of the survey are described by McDaniel and Stephenson.<sup>[3,4]</sup> A 5-point Likert scale was used to code participant responses. Thus, after each survey statement, participants were asked to mark whether they strongly agreed, agreed, neither agreed nor disagreed, disagreed, or strongly disagreed with the statement. Stephenson and Stephenson<sup>[3]</sup> compiled a list of all questions used in this survey for both forms. Survey items are organized under the constructs to which they apply. When presented to the carpenter apprentices, the questions were randomized into form A and form B. The individual questions and constructs that they address for both forms are contained in Part 1 of this report and are published in this issue of this journal.<sup>[3]</sup>

### Training materials

The final training program consisted of a 30-min PowerPoint presentation/interactive discussion led by an instructor. In this case, the first author served as the instructor. This was followed by a demonstration and hands-on activities designed to help trainees learn how to fit hearing protectors. Total time for training was about 45 min. This was designed to fit into a typical training period at the carpenter apprentice training centers where the training was administered. The training was also designed such that each of the constructs believed to influence behavioral intentions to use HPDs was addressed at least twice. The training content had a high face validity for the apprentices because it was grounded in relevant examples drawn from a task-based exposure model of carpentry tasks and stressed each task's potential for causing noise-induced hearing loss.<sup>[1]</sup>

To ensure that the training was engaging, a multimedia approach was used, which included two short videos embedded within the PowerPoint presentation. One of these videos principally addressed susceptibility to hearing loss, social norms, and barriers to HPD use. The other video principally addressed consequences of inaction and self-efficacy. Thus, all of the constructs noted above were addressed by the training materials. Both training videos were primarily shot in Cincinnati and at the carpenter training center in Monroe, OH. One video employed one professional actor and the other employed two professional actors. All other characters were volunteers, the majority of whom were carpenter trainers and apprentices. It is noted that these apprentices were senior to those who participated in the study, and were not themselves otherwise involved in this effort. Incorporating carpenter apprentice peers and respected older carpenters into the training materials established training legitimacy and provided positive role models. The Communication Planning Manual from the CDC office of health communication provided guidance that was useful when developing the scripts for each video.<sup>[5]</sup>

### **Audiometric monitoring**

In conjunction with the training, the carpenters also received a hearing test and counseling on the results. Audiometric tests employed automatic audiometers using a modified Hughson–Westlake procedure with TDH-49 headphones and MX41-AR ear cushions. Testing was performed by an occupational hearing conservationist certified by the Council for Accreditation in Occupational Hearing Conservation. An on-site audiologist reviewed each audiogram and counseled participants on the results. At the Monroe, OH, site, audiometric testing was conducted in a single-wall audiometric test booth. At the Indianapolis, IN, site, testing was conducted in a mobile test booth. Audiometers and audiometric test spaces met appropriate ANSI standards. Daily listening checks and bioacoustic calibration checks were also performed on the audiometers. Background noise was continuously monitored, with the caveat that monitors were calibrated to OSHA background noise specifications.

### **Hearing protector selection**

Not surprisingly, focus group responses indicated that the principle reasons for not using HPDs were consistent with the 5 C's: comfort, convenience, communication (i.e., perceived inability to hear speech and other important sounds such as warning signals), cost, and the safety culture/climate.<sup>[2]</sup> As was indicated above, the training was specifically designed to address these barriers, and a wide selection of hearing protectors was distributed to each participant during each training session. The selection of HPDs was intended to be responsive to the particular barriers identified by the focus groups. The formative research and procedures surrounding these focus groups was discussed in Part I of this effort.<sup>[3]</sup> The HPDs provided to each of the participants included:

- one lightweight helmet-mounted muff with foam ear cushions,
- two canal caps – one with foam tips and one with pre-molded tips mounted on an articulated headband,
- three formable foam earplugs,
- one earplug with a plastic stem and a foam tip,
- one pre-molded earplug with a coiled cord that attached to safety glasses or eyeglasses and
- four corded pre-molded earplugs, one of which came in two sizes and one of which was advertised as having a relatively “flat” (i.e., uniform) attenuation from low to high frequencies.

Participants were provided with several different cases for their earplugs, some of which were designed such that the case could be clipped to a belt loop, attached to a belt, or attached to a hard hat. Participants were initially provided with a 6-month supply of hearing protectors. Supplies of disposable earplugs, ear muff cushions, pre-molded earplugs, and earplug cases were provided to each training center. Participants were instructed to request replacements as needed. Participants were also provided with contact information to reach the principle investigator if they needed additional hearing protectors and were unable to get them at a training center, e.g. if an apprentice was at a remote job site. In fact, on three occasions, the principle investigator did mail replacements to participants.

### **Procedure**

Training was delivered either in an individualized setting or in a classroom setting. Classroom sizes averaged between 15 and 20 apprentices. Individualized training consisted of one-on-one instruction or instruction presented to teams of two apprentices. Individualized training was conducted at the Cincinnati apprentice training center and classroom training was conducted at the Indianapolis training center. The Ohio location was chosen for the individualized instruction because it was close to NIOSH and the experimenters could reasonably make the near-daily trips to conduct individualized instruction. Because this training was designed to be incorporated into existing carpenter health and training schedules, the individualized and classroom training (for both Year 1 and Year 2) were conducted in single sessions that required 45–60 min.

The order of events was as follows: explanation of the study and filling out consent form, completing the pre-training 28-item survey, audiometry, discussion of audiometric results, multimedia training presented one-on-one or in a classroom, practice fitting HPDs, and post-training 28-item survey. Even for those participants who received classroom multimedia training and HPD-fitting demonstrations, the instructor would walk around the room to individually confirm correct fitting. Practice was given with formable earplugs as well

as with pre-molded earplugs, including selecting the correct earplug size when applicable. At the end of the training session, participants were given their supply of hearing protectors and encouraged to try each of them in various work situations. Because survey forms A and B were equivalent, administration was randomized and half of the participants completed form A prior to training and form B post training, and vice-versa.

Approximately 12 months following the initial training, participants returned to their respective training centers to receive follow-up audiometry and training. This training was identical to the initial training, except that the order of the survey forms was reversed. Thus, participants who had filled out survey form A prior to the initial training session were administered form B prior to the 12-month follow-up training session, and so forth. The rationale for using the same training materials in year 2 was based upon our application of the Transtheoretical Model, which postulates stages of change in attitudes and beliefs. Thus, administering the training twice provided an opportunity to observe the effect of repeated training on attitudes and beliefs.

### Data analysis

Data were analyzed using ordinal logistic regression models.<sup>[6]</sup> Such models are derived from logistic regression models with binary outcomes; ordinal logistic regression models differ in that they allow for more than two categories of (ordinal) responses. Subjects were treated as random factors thus taking into account the likely possibility that repeated measures from the same individual would be correlated. In general, such models can estimate the probability that a response will be smaller or larger than a given category of response. For example, the model could estimate the probability that a response will be smaller or larger than the response “2.” If one thinks of the response variable as a continuous variable  $y_i$ , then the probability that  $y_i$  is greater than a given categorical response  $s$ , is:

$$\Pr(y_i > s | x_{1ij}, x_{2ij}, x_{3ij}, x_{4i}, x_{5i}) = \frac{\exp(\beta_0 + \xi_{0i} + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \beta_4 x_{4i} + \beta_5 x_{5i} - \kappa_s)}{1 + \exp(\beta_0 + \xi_{0i} + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \beta_4 x_{4i} + \beta_5 x_{5i} - \kappa_s)}$$

Where,  $s = 1, 2, 3,$  or  $4$  (with five possible answers for a question, one would only be interested in determining the probabilities of being greater than categories 1–4),

$x_{1ij} = 1$  for subject  $i$  responding to question  $j$  administered before training in the first year of participation and  $x_{1ij} = 0$  otherwise,  $x_{2ij} = 1$  for subject  $i$  responding to question  $j$  administered before training in the second year of participation and  $x_{2ij} = 0$  otherwise,

$x_{3ij} = 1$  for subject  $i$  responding to question  $j$  administered after training in the second year of participation and  $x_{3ij} = 0$  otherwise,

$x_{4i} = 1$  if subject  $i$  is from Cincinnati and  $x_{4i} = 0$  if subject  $i$  is if from Indianapolis,

$x_{5i} =$  age of subject  $i$ ,

$\beta_0 + \xi_{0i} =$  overall intercept for subject  $i$ .<sup>[6]</sup>

The model assumes that the coefficient for a subject answering a question in year 1 after training would be 0.0; thus, there is no parameter to indicate post-training testing for year 1. A negative coefficient in Equation (1) indicates that, as the explanatory variable  $x$  increases, the probability of having a lower response increases. The  $\kappa_s$ 's are parameters that are often referred to as thresholds. The models make the proportional-odds assumption, meaning that the odds ratio of

$$\frac{\{\Pr(y_i > s | x_i) / (1 - \Pr(y_i > s | x_i))\}}{\{\Pr(y'_i > s | x'_i) / (1 - \Pr(y'_i > s | x'_i))\}}$$

is the same, regardless of the choice of  $s$ . The ordinal logistic regression modeling was performed using the procedure *gllamm* in Stata.<sup>[7]</sup>

### Results

A total of 103 apprentice carpenters participated in the Year 1 training. Of these, 54 (53 male and one female) were located at the Monroe, OH, training center and 49 (46 males and three females) were located at the Indianapolis, IN, training center. Mean age for the Monroe participants was 28 years, and the median age was 26 years (range 19–46 years). Mean age for the Indianapolis participants was 30 years, and the median age was 29 years (range 20–50 years). Hearing threshold levels at the beginning of the study are shown in Table 1 for participants at each study location. The audiometric configuration (i.e., the high-frequency hearing loss, particularly the notch indicated at 6 kHz) is consistent with noise-induced hearing loss observed in previous NIOSH studies of carpenters.<sup>[2,8]</sup> Because the focus of this paper is on the relationship of training to attitudes and beliefs, the audiometric data will not be further discussed. However, these data are being addressed in a separate NIOSH effort focused on audiometric protocols for determining the work-relatedness of hearing loss.

Historically, both training centers reported that approximately 80% of the apprentices would complete the 4-year training program. We selected participants who would still be enrolled in the apprentice training program at the end of the NIOSH study. Thus, we expected about 80 participants to complete the study. Unexpectedly, only 42 participants completed the Year 2 training (26 from Indianapolis and 16

from Monroe). After discussing this with the training center staff, the attrition was attributed to the economic downturn in the construction industry, unavailability of construction work, and a corresponding dropout of apprentices from training programs.

The results clearly demonstrate a powerful training effect regarding HPD use. The z-scores in Table 2 are the estimates of the coefficients divided by the standard errors. (It should be noted that Table 2 mainly provides the basis for Table 3.) The  $P$ -values shown in Table 2 are twice the probability of obtaining a value more extreme than the z-score. For example, for city, the z-score is  $-0.1858/0.0969 = -1.9174407$ , and the  $P$ -value (from the standard normal distribution) is two-times the probability of obtaining a value  $< -1.9174407 = 2 * 0.02759098 = 0.05518197 \approx 0.055$ .  $P$ -values in the table may differ slightly from those obtained from the estimates and standard errors in the table, because the  $P$ -values shown were actually obtained before rounding the estimates and standard errors to four places. The variance for the random intercept  $\zeta_{0i}$  is 0.2863 and thus an estimate of the intra-class correlation of  $y_i$  is  $\frac{.2863}{.2863 + \left(\frac{P^2}{3}\right)} = 0.0801$ .

Using the above results, we took linear combinations of

$\hat{\beta}_1$ ,  $\hat{\beta}_2$ , and  $\hat{\beta}_3$  to determine whether significant changes occurred in going from one testing to another. For example, to see if the test scores changed significantly in going from pre-training tests given to the subjects in the first year of participation to the post-training tests given in the second year, we calculate  $0.0098 - 0.7694 = -0.7596$ . Bear in mind that if we are making a comparison with the post-training results from the first year of participation, we use 0.0 as the basis of comparison. Thus, if we wish to compare the post-training results from the subjects' first year of participation with the pre-training results of the subjects' second year, we take  $0.1729 - 0.0 = 0.1729$ . A negative difference in the coefficients indicates an increase in the desired direction, i.e. response categories tend to be lower. The effect due to test form (A or B) was initially included in the above model and was found to be non-significant. Thus, test form was not included in the final model. This was not unexpected because, during the survey development, the forms were demonstrated to have been equivalent.

The results of comparing survey outcomes from different test sessions are given in Table 3. Although there is evidence of training decay during the interval between training sessions, it is equally clear that there is still a significant positive training effect 1 year after the initial training, as evidenced by comparing the Year 1 pre-training results with the Year

**Table 1: Initial hearing threshold levels among apprentice carpenters at the Monroe, OH, and Indianapolis, IN, training sites**

Frequency	500	1000	2000	3000	4000	6000	8000
Indianapolis							
Right ear	6.6	4.4	4.4	6.0	7.8	18.3	14.8
Left ear	8.2	4.1	5.4	10.3	12.0	21.8	15.0
Monroe							
Right ear	10.5	11.0	7.2	10.8	14.1	17.7	14.6
Left ear	11.3	11.1	9.3	14.4	17.5	21.3	18.2

**Table 2: Estimates of parameters for an ordinal logistic regression model of carpenter data using all the questions for all four test sessions**

Parameter	Estimate	Std. err.	z	$P >  z $ ( $P$ -value)	95% confidence interval	
$\hat{\beta}_1$ (pre-1)	0.7694	0.0423	18.20	0.000	0.6865	0.8523
$\hat{\beta}_2$ (pre-2)	0.1729	0.0695	2.49	0.013	0.0367	0.3092
$\hat{\beta}_3$ (post-2)	0.0098	0.0696	0.14	0.888	-0.1267	0.1462
$\hat{\beta}_4$ (city)	-0.1858	0.0969	-1.92	0.055	-0.3758	0.0041
$\hat{\beta}_5$ (age)	-0.0130	0.0065	-1.99	0.047	-0.0257	-0.0002
$\hat{\kappa}_1$	-1.5762	0.2054	-7.67	0.000	-1.9787	-1.1736
$\hat{\kappa}_2$	0.4438	0.2047	2.17	0.030	0.0426	0.8449
$\hat{\kappa}_3$	1.3818	0.2052	6.73	0.000	0.9797	1.7839
$\hat{\kappa}_4$	3.0914	0.2092	14.78	0.000	2.6814	3.5013

**Table 3: Results of testing for changes in attitudes, beliefs, and behavioral intentions using results from the ordinal logistic regression model of responses to all questions for all four test sessions, as given in Table 2. The two-sided  $P$ -value ( $P > |z|$ ) is given for the null hypothesis that the difference is equal to 0**

Comparison	Difference in coefficients	Standard error	$z$	$P$ -value
Post-1–pre-1	-0.7694	0.0423	-18.20	0.000
Pre-2–post-1	0.1729	0.0695	2.49	0.013
Post-2–post-1	0.0098	0.0696	0.14	0.888
Pre-2–pre-1	-0.5965	0.0688	-8.67	0.000
Post-2–pre-2	-0.1632	0.0761	-2.14	0.032
Post-2–pre-1	-0.7596	0.0690	-11.00	0.000

2 pre-training results. The Year 2 training proved effective at eliminating the training decay, although there was no significant difference between the attitudes and beliefs after Year 2 than after Year 1.

To see whether the responses varied by construct, the responses to questions were modeled using model (1) above, but only with the data for each construct. Results for changes in test scores in different sessions are given in Tables 4a and 4b. When examining the results by individual construct, it becomes apparent why the training was so effective. For example, during the initial training (Year 1 pre- vs. post) of the 10 constructs that were measured, only two did not show a significant training effect (perceived severity of the consequences of inaction and social norms). The discussion below addresses these findings.

The results of testing for the effects of city and age at time of testing are given below in Table 5. Results are given for each of the 10 constructs tested. Generally, city and age were not found to be significant, although there were exceptions. City was found to be a significant variable for two constructs: HPD barriers (convenience) and social norms. Age was found to be a significant variable for HPD barriers (comfort) and behavioral intentions.

Table 6 shows the percentages of respondents who answered “Strongly Agree” or “Agree” to the given items in each of the constructs. Data represent the mean of all of the items within a given construct. For this analysis, survey data were normalized such that “Strongly Agree” and “Agree” always represented desired responses. For example, the “desired” responses to the survey item, *If I don't protect my ears, loud noise can damage my hearing*, would be to “Strongly Agree” or “Agree.” However, the desired responses to the item, *I don't think I have to wear hearing protectors every time I am working in loud noise*, would be to “Strongly Disagree” or “Disagree.” For negatively framed survey items such as these, responses were reverse scored as though they “Strongly Agree” or “Agree.” The results clearly showed how training increased the percentage of participants who agreed or strongly agreed with questions relevant to given construct areas. For constructs related to barriers to HPD use, self-efficacy, and behavioral intentions, the training effect

was especially pronounced. The greatest effect was found following the initial training session.

## Discussion

There was no overall main effect between the Indianapolis training site where participants received classroom instruction and a site in southwest Ohio (Monroe, OH) where participants received individualized instruction, i.e., either one-on-one instruction or instruction presented to a team of two coworkers. However, analysis of the four individual survey data sets as a function of city found that there was a significant difference between the two sites for the Year 1 pre-training survey data set. In particular, the participants at the Monroe, OH, site were found to have more positive attitudes and beliefs at the outset of the study. This difference disappeared following training. Although it is true that the Monroe participants had less room for improvement, these results also demonstrate that the training was able to bring all apprentice participants up to the same desired level with regard to attitudes, beliefs and behavioral intentions to use hearing protection properly. This also suggests that the training can be successfully administered in differing geographical locations with different baseline attitudes, beliefs, and behavioral intentions.

Nevertheless, there was no difference between the two sites following training. In other words, despite the slightly different baselines, both forms of instruction produced equivalent outcomes. This was a surprise as the training literature indicated that one-on-one training would be the “Gold Standard” in teaching. Several elements in the study design may have influenced the fact that the classroom instruction yielded the same outcome as individualized instruction. First, the training environments were similar. All training was conducted at an apprenticeship training center and all training was presented in an environment and time specifically set aside for occupational safety and health training. All subjects received identical training materials presented by the same instructors. The instructors individually observed each participant's ears after they fit HPDs in both the individualized training and in the classroom training. This was done to ensure mastery of HPD-fitting skills for all trainees as a goal of both types of instructional settings

**Table 4a: Results of testing for changes in attitudes for questions in specific constructs. The two-sided  $P$ -value ( $P > |z|$ ) is given for the null hypothesis that the difference is equal to 0**

Construct	Changes from one test session to another							
	Post-1-pre-1 (change in 1 <sup>st</sup> year)				Pre-2-post-1 (change from end of 1 <sup>st</sup> to beginning of 2 <sup>nd</sup> year)			
	Estimate	SE	$z$	$P$ -value	Estimate	SE	$z$	$P$ -value
1. Susceptibility	-0.8318	0.1783	-4.66	0.000	0.3395	0.2818	1.20	0.228
2. Severity	-0.1346	0.1745	-0.77	0.441	0.1832	0.2763	0.66	0.507
3. Benefits	-1.1465	0.1445	-7.94	0.000	0.5498	0.2246	2.45	0.014
4. Barriers								
a. Comfort	-1.1495	0.1323	-8.69	0.000	0.4694	0.2021	2.32	0.020
b. Muffles sounds	-1.8068	0.1820	-9.93	0.000	0.3644	0.2712	1.34	0.179
c. Communicate	-1.0952	0.1335	-8.20	0.000	0.3844	0.2091	1.84	0.066
d. Convenience	-0.5815	0.1111	-5.24	0.000	-0.1540	0.1810	-0.85	0.395
5. Behav. intent.	-0.8855	0.1348	-6.57	0.000	0.3012	0.2138	1.41	0.159
6. Social norms	0.1265	0.1727	0.73	0.464	-0.4026	0.2930	-1.37	0.169
7. Self-efficacy	-1.5468	0.1221	-12.66	0.000	0.3293	0.1828	1.80	0.072

**Table 4b: Results of testing for changes in attitudes for questions in specific constructs. The two-sided  $P$ -value ( $P > |z|$ ) is given for the null hypothesis that the difference is equal to 0**

Construct	Changes from one test session to another							
	Post-2-pre-2 (change in 2 <sup>nd</sup> year)				Post-2-pre-1 (change from beginning of 1 <sup>st</sup> to end of 2 <sup>nd</sup> year)			
	Estimate	SE	$z$	$P$ -value	Estimate	SE	$z$	$P$ -value
1. Susceptibility	0.0927	0.3170	0.29	0.770	-0.3996	0.2718	-1.47	0.141
2. Severity	0.3117	0.3137	0.99	0.320	0.3603	0.2696	1.34	0.181
3. Benefits	-0.6065	0.2577	-2.35	0.019	-1.2032	0.2275	-5.29	0.000
4. Barriers								
a. Comfort	-0.4650	0.2359	-1.97	0.049	-1.1452	0.2032	-5.64	0.000
b. Muffles sounds	-0.3884	0.3094	-1.26	0.209	-1.8307	0.2757	-6.64	0.000
c. Communication	-0.3949	0.2422	-1.63	0.103	-1.1057	0.2115	-5.23	0.000
d. Convenience	0.1140	0.2044	0.56	0.577	-0.6215	0.1815	-3.42	0.001
5. Behav. intent.	-0.3524	0.2383	-1.48	0.139	-0.9366	0.2132	-4.39	0.000
6. Social norms	0.1108	0.3159	0.35	0.726	-0.1653	0.2853	-0.58	0.562
7. Self-efficacy	-0.2761	0.2102	-1.31	0.189	-1.4936	0.1812	-8.24	0.000

**Table 5: Results of testing for the effects of city and age at testing for questions in specific constructs. The two-sided  $P$ -value ( $P > |z|$ ) is given for the null hypothesis that the effect is equal to 0**

Construct	Explanatory variable							
	City				Age tested			
	Estimate	SE	$z$	$P$ -value	Estimate	SE	$z$	$P$ -value
1. Susceptibility	-0.0996	0.2470	-0.40	0.687	-0.0063	0.0168	-0.37	0.709
2. Severity	-0.1595	0.2255	-0.71	0.479	-0.0131	0.0154	-0.85	0.396
3. Benefits	-0.0974	0.2027	-0.48	0.631	-0.0032	0.0138	-0.23	0.816
4. Barriers								
a. Comfort	-0.1071	0.1554	-0.69	0.491	-0.0219	0.0109	-2.01	0.044
b. Muffles sounds	-0.1752	0.2397	-0.73	0.465	-0.0316	0.0165	-1.91	0.056
c. Communication	0.0266	0.1772	0.15	0.881	-0.0201	0.0122	-1.65	0.100
d. Convenience	-0.6279	0.1936	-3.24	0.001	-0.0095	0.0131	-0.73	0.465
5. Behav. intent.	-0.3796	0.2216	-1.71	0.087	-0.0323	0.0150	-2.15	0.031
6. Social norms	-1.5767	0.4080	-3.86	0.000	0.0066	0.0270	0.25	0.806
7. Self-efficacy	-0.0591	0.1391	-0.43	0.671	-0.0102	0.0095	-1.07	0.284

and in order to comply with the Human Subjects Review board requirements. Also, each participant was individually counseled following his/her hearing test, regardless of how they were trained. Finally, the training was intended to be

quite comprehensive. Thus, it may simply be that an effective training program can work as well in a classroom setting as it does in a one-on-one setting. Therefore, the authors do not suggest that the present results should be generalized

**Table 6: Percentage of respondents who strongly agreed or agreed with the survey items**

Construct	Year 1 pre (%)	Year 1 post (%)	Year 2 pre (%)	Year 2 post (%)
Severity of consequences	90	87	88	86
Susceptibility to hearing loss	85	92	89	94
Benefits of preventive action	79	93	84	94
Barriers: Comfort	36	62	51	62
Barriers: Muffle important sounds	38	73	65	73
Barriers: Communication	36	63	53	62
Barriers: Convenience/availability	39	56	56	54
Social norms	18	15	29	21
Self-efficacy	45	81	77	86
Behavioral intentions	54	78	59	70

to infer that classroom instruction is always as effective as individualized instruction. Additionally, the effectiveness of classroom instruction in this study should not be interpreted as an indication that there is no need for individual instruction in an effective HCP. For example, individual HPD fit-testing is highly recommended. Likewise, individuals whose hearing has significantly changed from baseline hearing tests or who have a recordable hearing loss should receive individual instruction in steps they can take to prevent further occupational hearing loss. If any generalization can be made, it may be that the results from this study support the development of training in which attendees engage in hands-on activities that are assessed by the instructor for each student. In this way, the class is taught “to mastery” and one can be assured that each trainee has demonstrated and mastered any critical skills associated with the class. This approach can be used whether one is training one-on-one or in groups.

Study participants ranged in age from 19 years to 50 years. Given this range, it was not surprising to find an overall significant age effect. From Table 5, it appears that two constructs in particular were influenced by age differences: *Barriers – Comfort* ( $P = 0.044$ ) and *Behavioral Intent* ( $P = 0.031$ ). In both cases, older workers were more likely to have adopted positive beliefs and behavioral intentions. The authors had hoped to have a study sample with a relatively narrow age range, and it was assumed that limiting participants to an apprentice population would accomplish this goal. That turned out not to be the case. All of the training materials (i.e., both the video-based training content as well as the lecture materials) were presented by individuals >50 years old. This might explain why older participants exhibited a stronger intent to adopt hearing loss prevention behaviors. It would be of interest to see whether younger role models would have had a similar age-effect on the younger participants.

It is clear that the method used to develop and deliver training materials had a very powerful and positive overall training effect. The difference between the Year 1 pre- vs. post-training was highly significant. For example, the  $P$ -value for behavioral intentions, where  $z = -6.57$  is actually

0.0000000005. And, in fact, some of the constructs with smaller  $z$ -values have much smaller  $P$ -values.

As might have been expected (and as is discussed below), there was a significant decay of this training effect during the interval between the Year 1 and Year 2 training sessions ( $P = 0.013$ ). However, the Year 2 refresher training both reversed and overcame this decay, with the Year 2 training also having a significant positive overall effect ( $P = 0.032$ ).

Regarding individual constructs, the training proved highly effective at positively influencing participants’ attitudes and beliefs related to barriers and self-efficacy. For example, at the outset of the study, less than half (45%) of the participants felt they could use HPDs to prevent occupational hearing loss. This is interesting because even though the participants were apprentices, all had been working for at least a few months, and all had been exposed to HPDs at the training center. At the end of the study, 94% expressed a strong belief that they not only could use HPDs to protect their hearing but could also show a co-worker how to properly use HPDs. That the training so effectively addressed barriers and self-efficacy undoubtedly reflects the successful application of our eclectic theoretical perspective and the extensive focus group testing used to develop both the training content as well as the associated survey items.

Some elements of the training seemed at first to be less-effective at changing participants’ attitudes and beliefs (e.g., *Severity of Consequences*). This is thought to reflect a ceiling effect. Even at the outset of the study, approximately nine of 10 participants already believed that loud noise could cause them to lose their hearing. Thus, there was little room to show improvement.

As is addressed by the Theory of Reasoned Action, and discussed in Part I of this effort,<sup>[3]</sup> safety climate is an important variable associated with HPD use. For this reason, the survey included items that addressed social norms, specifically whether or not co-workers usually wore HPDs when working in noise. For the present study, at the beginning of the study, only 18% of the participants agreed or strongly agreed that

their co-workers usually wore HPDs, and by the end of the study, that had only improved to 21%. These data were not surprising. The reported HPD use at the outset of the study is in good agreement with the authors' initial study of self-reported HPD use among carpenters.<sup>[9]</sup> Because the training material for this study was not designed to address worksite safety climate, it is not surprising that there was no effect for social norms. However, the low incidence of reported HPD use, despite good intentions, is obviously a serious issue and points to the need for additional research designed to address work site safety climate and other environmental factors that are known to affect workplace safety. For example, as was noted above, there were initial differences between the Monroe and Indianapolis sites. Such research would be useful in identifying the bases for these differences and in developing training that would accommodate these differences.

Finally, the training was very effective at positively influencing participants' behavioral intentions to use HPDs when working in hazardous noise. Prior to the Year 1 training, only 54% of the participants expressed intent to use HPDs. This improved to 78% following the Year 1 training and, after typical training decay over time, rebounded to 70% following the Year 2 training. Compared with the first pre-training score, both the post-training scores reflected a significant ( $P < 0.05$ ) change over the pre-training behavioral intentions.

NIOSH conducted an associated study to collect behavioral observation data to corroborate actual HPD use among the apprentices who participated in this study. However, despite considerable expense and effort, it was not possible to gather enough repeated measures on enough apprentices on job sites to satisfactorily quantify actual HPD use. The apprentice training centers were regional facilities. Thus, in some cases, the apprentices assigned work sites varied daily and were many miles from the training center. In other cases, the training center staff was unable to determine apprentices' worksites on days on which observers were present. On other days, observers reported to worksites only to find that apprentices were not called in to work that day, and in far too many instances, apprentices simply dropped out of the program. In a few cases, the NIOSH observers were unable to obtain permission to enter the work site. Thus, it was not possible to conclude the extent to which behavioral intentions translated into actual work site behaviors.

As might have been expected, there was significant decay of this training effect during the interval between the Year 1 and Year 2 training sessions ( $P = 0.013$ ). However, the Year 2 refresher training both reversed and overcame this decay, with the Year 2 training also having a significant positive overall effect ( $P = 0.032$ ). These findings are important when addressing the need for follow-on (e.g., annual) training. Specifically, there was clear evidence of decline in desirable attitudes, beliefs, and behavioral intentions between Year 1 post-training and Year 2 pre-training ( $P = 0.013$ ). In

Year 2, there was a significant post-training rebound effect ( $P = 0.032$ ). This is consistent with the Stages of Change model, which argues that repeated exposure to a health and safety message should incrementally move recipients along a continuum, leading, ultimately, to maintenance of the desired behavioral change. From this perspective, the Year 2 training was not superfluous.

Although it may seem obvious that effective training should be framed to take into consideration content areas such as those used in this study, that is not always feasible unless a methodological approach is taken to gather needed information when developing new training. Taking the time to conduct a needs assessment and gather formative information about existing concerns from your target audience will ensure that important constructs are identified. For example, while some general constructs like "need to hear sounds" tend to surface for most groups dealing with hearing protector use, the specifics related to this barrier frequently varies widely from group to group. One study of coal miners found a near-universal concern that HPD use would prevent them from hearing "roof talk" (i.e., the noise occurring shortly before the mine walls or roof collapse). Armed with this information, HCP training specifically addressed the fact that roof talk was dominated by low frequencies for which typical HPDs offered little attenuation.<sup>[1]</sup> Even in the present study, follow-on probing to participant's responses identified a surprising situation associated with the safety climate. In this case, participants ran out of an earplug that was colored red, white, and blue. When asked about this, the instructor learned that at one job site where these participants worked, a foreman complained about the time needed to insert formable earplugs. However, the red, white, and blue earplugs were considered to be "patriotic," and the foreman did not discourage the participants from using these devices. Thus, because there are an unlimited number of occupational environments, employing a methodical approach for identifying workers' pre-existing attitudes, beliefs, and behavioral intentions associated with preventing occupational hearing loss is critical to the process of developing effective HCP training and evaluating program effectiveness.

## Conclusion

When control technologies are not possible or feasible, using hearing protectors is the only option for reducing noise exposure. Education and training that only imparts factual information are unlikely to substantially motivate workers to actually use hearing protectors when and how they should be worn. Health communication theory and numerous health promotion models argue that education and training must be designed to positively influence behavioral intentions to perform an activity (e.g., use hearing protectors). Without first establishing this behavioral intention, the actual behavior is unlikely to follow. Likewise, behavioral intentions are influenced by several antecedents. For example, in order to foster behavioral intentions to use hearing protectors, education and training must ensure workers understand both the severity

of their risk of hearing loss as well as the benefits of preventive actions, including when and how to wear hearing protectors. Training must focus on specific barriers to hearing protector use and also ensure a high degree of self-efficacy to effectively use hearing protectors to preserve one's hearing health.

The present study employed a series of focus groups to understand carpenters typical attitudes, beliefs, and behavioral intentions related to occupational hearing loss. Results of these focus groups were used both to develop a hearing conservation training program as well as to develop a survey tool designed to measure these attitudes, beliefs, and behavioral intentions. The resulting training program proved to be highly effective at positively shaping apprentice carpenters' beliefs that they could use hearing protectors to prevent occupational hearing loss. This was true for training delivered in a one-on-one setting as well as with training delivered in a traditional classroom setting. Consequently, participants demonstrated a significant improvement in their expressed behavioral intentions to use hearing protectors. This outcome was a function of having developed an educational and training program that specifically addressed issues known to influence carpenters use of hearing protectors. In general, generic educational and training materials are likely to provide only "hit or miss" content relevant to the needs of a given audience. Based on the present results, it is recommended that hearing conservation education and training programs be specifically tailored to sharply focus on variables known to affect the target audiences' attitudes and beliefs, particularly with regard to barriers preventing effective use of noise controls and hearing protection.

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### Address for correspondence:

Mark R. Stephenson,  
NIOSH, 4676 Columbia Parkway,  
Cincinnati, OH 45226-1998, USA.  
E-mail: [mstephenson@cdc.gov](mailto:mstephenson@cdc.gov)

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