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Preventing Noise-induced Hearing Loss in Construction Workers

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Title of Project

Preventing Noise-induced Hearing Loss in Construction Workers

Period of Support

9/30/93-9/29/97*
*Included a one-year, no-cost extension.

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List of Abbreviations

Abbreviation	
dB(A)	Decibels
HPDs	Hearing protection devices
HPM	Health Promotion Model
NIHL	Noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
USDHHS	United States Department of Health and Human Services

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Significant Findings

A number of significant findings resulted from this project. These findings are relevant to practicing occupational health professionals and to researchers interested in understanding or changing workers' behaviors.

- The predictor-based training program intervention significantly improved use of HPDs by plumber/pipefitters (regional sample) and by plumber/pipefitter trainers (national sample). This effect was demonstrated while controlling for other effects by random assignment in a Solomon Four-Group design and through use of covariance analyses. The regional sample's use increased from 37% to 50% pre intervention to post intervention (a 13% increase in use). This percent represents the proportion of the time they wore HPDs when they were in high noise. Although their level of use does not approach the desired level of use, 100% of the time needed, the intervention effect was responsible for a 35% improvement over baseline use.

- For the national sample, the intervention was responsible for a 43% improvement over baseline use, increasing use of HPDs from 40% to 57% of the time they should be used.

- A comprehensive, accurate, high quality training program for increasing construction workers' use of HPDs was developed and will be nationally distributed. The final product incorporates feedback from users and reviews by consultants.

- The Health Promotion Model (Pender, 1987) **(Figure 1)** proved to be a useful conceptual model for explaining construction workers' use of HPDs, accounting for about one-half of the variance in HPD use. Predictors from this model provided the bases for the training program intervention which was developed and tested through the project. Identification of this relevant model allows for comparability of predictors, conceptual frameworks, and results by other researchers and practitioners.

- Construction workers' use of HPDs is inadequate to prevent noise-induced hearing loss. When HPDs should have been used (working in high noise), self-reported mean use of HPDs ranged from 18% to 50% of the time by the three trade groups studied.

- Large proportions of the construction workers studied reported exposure to high noise and perceptions of hearing loss, with some reporting hearing loss found through a hearing test.

- Analyses of the data from the Solomon Four-Group design showed that the pretest measurement of predictors of use of HPDs and of use of HPDs did not have a significant effect on postintervention use of HPDs. Future studies, then, can dispense with the test of the effect of pretests, thereby using either smaller total samples, or having larger groups exposed to the intervention.

- Written questionnaires to measure workers' perceptions of HPDs and predictors of their use were validated, with acceptable reliability for use with these trade groups of construction workers.

Usefulness of Findings

The findings from this study are of benefit both to the workplace and to researchers focusing on understanding or changing construction workers' behavior.

- The Health Promotion Model (HPM) proved to be a useful conceptual model for explaining construction workers' use of HPDs. Predictors from this Model provided the bases for a comprehensive training program. This predictor-based training program significantly improved use of HPDs by plumber/pipefitters (regional sample) and by plumber/pipefitter trainers (national sample). With this consistency of effect on a regional and national sample of plumber/pipefitters, it is expected that this training program will be effective with other members of this trade group.

- The training program developed in this project benefited not only from the data obtained via the project, but also from input provided by expert consultants in the field. This training program represents a comprehensive, accurate, high quality approach for training construction workers to increase use of HPDs.

- Increased use of HPDs will prevent NIHL, an irreversible impairment. Prevention of NIHL will result in increased quality of life for workers and cost savings for individual workers, health insurers, and workers' compensation programs. The intervention in this study significantly increased use of HPDs by plumber/pipefitters.

- Significant contributions to research and science were also made with this study. Instruments to measure workers' perceptions of HPDs were developed and tested. Each instrument achieved acceptable reliability for use with the population of workers.

- The identification of the predictors of workers' use of hearing protection provides a scientific base for this research and other researchers' work to prevent NIHL.

- Baseline data were obtained and published regarding construction workers' use of HPDs and their perceptions of noise exposure and hearing loss. This information has not previously been reported and increases understanding of the barriers to preventing NIHL.

- The successful recruitment, participation, and retention of subjects obtained through trade union groups supports this mechanism of accessing subjects.

- Further analyses are being conducted to determine factors which may have contributed to the non-significant effect of the training program on the other two trade groups.

- There is a need for further study of the personal, job, and worksite characteristics of carpenters and operating engineers, the two trade groups who did not significantly increase their use of HPDs.

Abstract

Hazardous noise, which affects 30 million workers in the United States, can destroy hearing and cause physiological and psychological stress (NIOSH, 1996). Construction workers are a large, diverse, and mobile group with work that involves multiple sites, activities, and environmental conditions. Factors unique to the construction industry, such as a mobile work force, subcontracting, multiple employers and job sites, multiple sources of noise in job sites, difficulty in controlling noise through engineering efforts, and hearing conservation programs that are less comprehensive than those for manufacturing workers, support the need for individual workers' use of hearing protection devices (HPDs).

The purpose of this project was to test the effectiveness of a training program to increase use of hearing protection devices (HPDs) by three trade groups of construction workers: carpenters, operating engineers, and plumber/pipefitters. This was conducted in three phases: Phase 1 identified predictors of use; Phase 2 use the identified predictors to design and pilot test a training program intervention; and Phase 3 tested the effectiveness of the intervention. In Phase 1, 356 construction workers from the three trade groups completed questionnaires measuring their perception of the frequency of use and predictors of their use of hearing protection, and their perceptions regarding their noise exposure and hearing loss. The Health Promotion Model (HPM)(Pender, 1987) provided the framework for identifying the important predictors of use of HPDs. These predictors then served as the bases for the intervention which was pilot tested in Phase 2 with representatives of the three trade groups (n=33).

In Phase 3, the effectiveness of the intervention was tested with three regional groups of workers representing the three trade groups and a national sample of plumber/pipefitter trainers. The effectiveness of this theory-based intervention (video, pamphlets, and guided practice session) was assessed using a Solomon Four-Group design (n=1028) with the posttest measures occurring ten to twelve months after the intervention.

The subjects were predominately Caucasian males. The three trade groups in the regional sample differed on several demographic variables: operating engineers were the oldest group, had less education, and reported more hearing loss than the other two trades; and both operating engineers and carpenters reported more noise exposure on the job than plumber/pipefitters reported.

No demographic variables were significantly related to posttest use of HPDs. Pretest use, pretest intention to use, and posttest use of HPDs were significantly correlated (.23 to .39), but not as highly correlated as might have been expected.

While two of the three trade groups in the regional sample increased their use of hearing protection from pretest to posttest, only the plumber/pipefitter group showed a significant main effect of the intervention. This effect was seen in both the regional sample of plumber/pipefitters and the national sample of plumber/pipefitter trainers. The regional group of plumber/pipefitters increased their use from 37% to 50% of the time needed, a 13% increase, representing a 35% improvement over their pretest use. The national group increased from 40% to 57%, a 17% increase, a 43% improvement over their pretest use. Both pretest use and pretest intention to use HPDs represented significant covariates of post test use for these two groups.

The pretest measurement of use of hearing protection and of predictors of that use, did not have an effect on the impact of the training. Therefore, future studies may elect not to use a Solomon Four-Group design to control for the pretest effect. Additional studies are needed to identify personal and job characteristics of carpenters and operating engineers which may have contributed to the lack of intervention effect.

Revisions were made in the intervention program based upon these results and feedback from project consultants. Negotiations are underway for the national distribution of the training program package which includes a video, training manual, two brochures, and sample HPDs.

Body of Report

Purpose

The purpose of this project was to test the effectiveness of a training program, developed specifically for construction workers and based upon significant predictors from a conceptual model, in increasing use of HPDs by three trade groups of construction workers.

Specific Aims

1. Identify the most important predictors of construction workers' use of hearing protection, specifically for carpenters, operating engineers, and plumber/pipefitters.

2. Use the identified predictors of construction workers' use of hearing protection to adapt the training program already developed for factory workers to the needs of construction workers.

3. Assess the effect of the training program on construction workers' use of hearing protection.

4. Revise the training program as indicated and make it available for general use with construction workers.

Background

Statement of the problem

About 30 million workers in the United States are exposed to hazardous noise in manufacturing work (NIOSH, 1996), resulting in notable costs in dollars and human suffering due to NIHL (NIOSH, 1986; Shipley, 1985; Gasaway, 1985; USDHHS, 1991). Personal safety and personal relationships are also negatively affected by hearing loss. Factors unique to the construction industry, such as a mobile work force, sub-contracting, multiple employers and job sites, multiple sources of noise on job sites, difficulty in controlling noise through engineering efforts, and hearing conservation programs that are less comprehensive than those for manufacturing workers, support the need for individual workers' use of hearing protection devices (HPDs). The hearing conservation program requirements for construction workers are less comprehensive than those for industrial workers in that they do not require periodic noise monitoring, dosimetry, audiometric testing, or worker education (Franks, 1990).

No published reports documented the extent of use of HPDs by construction workers, but informal information suggests it is inadequate. Thus, there was a need to: 1) determine actual use of HPDs, 2) identify predictors of use, and 3) assess effectiveness of programs to increase use of HPDs in order to achieve the ultimate goal of preventing noise-induced hearing loss (NIHL).

Review of the Literature

The construction industry is comprised of skilled and semi-skilled workers who engage in a wide variety of activities, in many settings. Construction workers are often self-employed (U. S. Bureau of Census, 1992), self-supervised (Lange & Mills, 1979), and conduct their activities in areas that are not amenable to environmental and engineering controls. The National Occupational Exposure Survey resulted in estimates that 507,049 workers in construction were exposed to noise levels of 80-85 dB(A) or greater (Franks, 1988). Little information is available regarding the duration and intensity of noise exposures (Franks, 1988; Schneider, Eckhart, Belard, & Engholm, G. 1995; Schneider & Susie, 1993).

Links have been suggested among noise exposure, hearing damage, and other workplace injuries and stress-related diseases (Waller, Payne, & Skelly, 1989; Kilburn, Warshaw, & Hanscom, 1992; Lusk, et al., 1996). In 1990, injury and illness rates for the construction industry (14.2 per 100 workers) were higher than those for mining (8.5), agriculture, forestry and fishing (11.6), and manufacturing (13.2) (U.S. Bureau of the Census, 1992). Noise, hearing loss, and balance dysfunction have been implicated in injuries (Waller, Payne, & Skilly, 1989; Kilburn, Warshaw, & Hanscom, 1992). Noise has also been implicated as a factor in the development of cardiovascular and stress-related diseases (Lusk, Ronis, & Hogan, 1997; Sloan, 1991; van Dijk, 1987; DeJoy, 1984; Cohen & Weinstein, 1981).

These potential non-auditory effects of noise exposure, as well as the known effects on hearing, all support the need to reduce exposures. The best way is to equip construction workers (a mobile and diverse workforce) to protect themselves from noise through use of HPDs by individual workers.

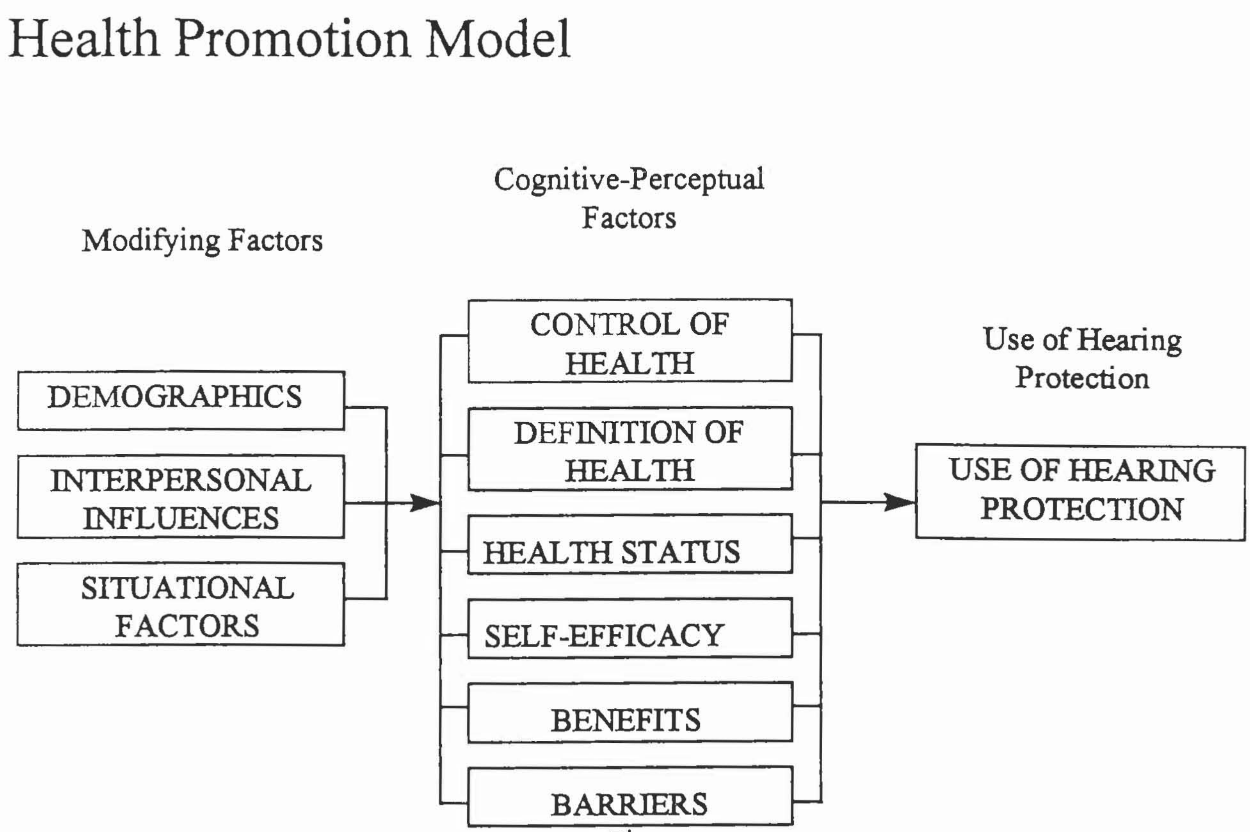
The need to use a conceptual framework to understand workers' behaviors has been well supported (McAfee & Winn, 1989). Further, the importance of a conceptual basis to guide behavioral intervention programs is also well accepted (Fishbein, et al., 1991; Goldenhar & Schulte, 1994). This project used the Health Promotion Model (**Figure 1**) to identify predictors of worker behavior which then guided the content and process of the training program intervention.

Methods

Study design

A cross-sectional, correlational study was used to identify predictors of use of hearing protection in selected groups of construction workers (Specific Aim 1). Identified predictors of construction workers' use of hearing protection devices (HPDs) were used to design a training program (Specific Aim 2). The effect of the training program on use of HPDs was measured through random assignment of groups of construction workers to a Solomon Four-Group design with postintervention measures 10-12 months following the training program (Specific Aim 3). The training program was revised and arrangements are being made for national distribution (Specific Aim 4).

Figure 1: Health Promotion Model



Note. From Health Promotion in Nursing Practice (2nd ed.) (p. 58) by N. Pender, 1987, Norwalk, CT: Appleton & Lange. Copyright 1987 by Appleton & Lange. Adapted with permission.

Procedure

In Phase 1 of the study, construction workers (carpenters, operating engineers, and plumber/pipefitters) were selected from their respective trade organization rosters of workers attending regional trade association training programs. This regional sample of unionized workers included 118 carpenters, 109 operating engineers, and 129 plumber/pipefitters (total n=356).

Although it was originally planned to have a sample of non-union carpenters included in the study, their training coordinators were not successful in recruiting subjects to participate in Phases 1 and 3 of the project. However, the Executive Director and Education Coordinator did assist the project by having 40 non-union carpenters pilot test questionnaires for the study.

In addition, 144 attendees at a national certification program to become Plumber/Pipefitter trainers were selected.

Participants filled out a questionnaire, attractively presented in booklet form, which required approximately 35-40 minutes to complete.

In Phase 2, a sample of 33 workers from the three unionized trade groups in the regional sample were included in a pilot-test of the training program. The training program consisted of: videotaped information on hearing health and conservation presented by actors portraying an occupational health nurse and construction workers; sample HPDs; a practice session guided by trainers; and a brochure. In addition to completing feedback forms, these construction workers participated in focus groups to provide further feedback and evaluation of the training program.

In Phase 3, construction workers were randomly assigned, usually by naturally occurring training groups, to the Solomon Four-Group design: group one received the pretest; group two received the pretest and the intervention; group three received the intervention only; and group four served as a control group and received only the posttest. The posttest data were collected ten to twelve months following initial delivery of the intervention. **Table 1** presents the numbers participating at posttest, those originally recruited at the pretest stage, and the retention rates for each trade group of unionized workers.

Table 1: Retention Rate for Samples

	Regional									National		
	Carpenters (N=208)			Operating Engineers (N=356)			Plumber/Pipefitters (N=234)			Plumber/Pipefitters (N=230)		
Group	post	pre	%	post	pre	%	post	pre	%	post	pre	%
P Only	56	83	68	99	109	91	59	78	76	50	75	67
P + I	41	85	48	83	98	85	75	83	90	55	75	73
I Only	61	74	82	93	105	89	48	71	68	64	84	76
Control	50	101	50	81	108	75	52	98	53	61	174	35
Total	208	343	61	356	420	85	234	330	71	230	408	56

In assigning the national certification program attendees to the Solomon Four-Groups, after the required number of subjects had been allocated to the 3 groups for data collection or intervention, all other attendees in the education courses were identified as controls. When the posttest data collection occurred the following year, there was a poorer response from the control group. Even though their names were announced and they were asked to come to the site to complete questionnaires, only a small proportion did so. This was likely due to the fact that they were unaware that they were part of a study and that they felt no identity with it.

In an attempt to obtain data from these subjects and from those who did not return for that subsequent annual session of their certificate training program, questionnaires were mailed to their homes, but this yielded a very minimal response.

An additional regional sample of non-union carpenters was planned and extensive efforts were made to recruit these subjects. Although training coordinators promised cooperation and participation, and despite many scheduled visits to the training center and extensive efforts by project staff, few subjects in this group were accessed for the study. Thus, the final samples used for analyses included only unionized workers.

Measurement of Variables

Questionnaires were presented in an attractive booklet format. The concept, scales measuring the concept, and the reliabilities of the scales are reported in **Table 2** and in the following sections excerpted from the publication reporting the causal model results (Lusk, Ronis, & Hogan, 1997).

> **Interpersonal influence**, perceptions regarding others' beliefs regarding use of HPDs, was measured using three scales adapted for this study from a 28-item scale developed by the Child/Adolescent Behavior Research Center at the University of Michigan (Nola J. Pender, personal communication, March 16, 1993) measuring social support for exercise behavior,

interpersonal norms, interpersonal support, and interpersonal modeling. Interpersonal norms concept was measured through questions about the respondents' beliefs about how much others (family members, friends, supervisor, and coworkers) think they should wear hearing protection. Interpersonal modeling was measured through two questions about how much respondents believed others use hearing protection when exposed to noise, specifically their supervisor and the coworker with whom the respondent spends the most time.

Situational factors were measured by two scales developed for this program of research. The first determined perceptions of accessibility and availability of hearing protection equipment and contained items such as "ear plugs are available to pick up at my job sites." The second scale defined high noise levels as "when you have to shout to be heard by a coworker who is 3 feet or less away from you" and asked how often they were exposed to this level of noise.

Perceived control, the extent to which the individual feels in control of his health, was measured by the Perceived Health Competence Scale (Smith, Wallston, & Smith, 1995). An example of an item from this scale is "I'm generally able to accomplish my goals with respect to my health."

Definition of health, the individual's perception of the meaning of health, was measured using a revised form of Laffrey's Health Conception Scale (Laffrey, 1986). The revision process is reported in detail elsewhere (Lusk, Kerr, & Baer, 1995a); the clinical health scale was used in its original form and a new "overall wellness" subscale was created. A sample of an item from the clinical health subscale is "being free from symptoms of disease," and from the new overall wellness subscale is "feeling great – on top of the world."

Perceived health status, the individual's conception of current health, was measured by the health subindex of the Philadelphia Geriatric Center Multilevel Assessment Instrument (Lawton, Moss, Fulcomer, & Kleban, 1982). A sample item from this scale, measured on a 4-point scale from *excellent* to *poor*, is "How would you rate your overall health at the present time?"

Perceived self-efficacy, the extent to which individuals have confidence in their ability to perform the activity, was measured by the Self-Efficacy in Use of Hearing Protection Scale developed for this program of research. An example of an item from this scale is "I am sure I can use my hearing protection so it works effectively."

Perceived benefits of use of hearing protection, beliefs regarding the positive results of the behavior, were measured by two scales developed for this program of research. The measurement of benefits of use of hearing protection was modeled on a benefit and barrier to exercise scale developed by Murdaugh & Hinshaw (1986). A sample item for that scale is "Wearing hearing protection protects me against hearing loss from noise exposure." The measure for the value of use of hearing protection, modeled on Pender's value of outcome exercise scale (Personal communication, December 12, 1986), used a visual analogue scale to assess the degree of importance of such items as "keep out noise," or "protect my hearing."

Perceived barriers, the real or perceived impediments to engaging in the behavior, were measured by the Barriers to Use of Hearing Protection scale developed for this program of research, but modeled on the Murdaugh and Hinshaw (1986) instrument. An example of an item in this scale is "Hearing protection keeps me from hearing what I want to hear."

The latter four scales developed by the researchers and described above were reviewed by expert panels to establish construct validity. Further, in the analyses of data from factory workers, the paths from each construct to its measures were all significant beyond the .001 level, providing support for validity of all of the scales.

The dependent variable, **use of hearing protection**, was defined as wearing ear plugs or ear muffs. It was measured by workers' self-report of the percent of time (0-100%) they used hearing protection during the past week, month, and 3 months when they were in high noise areas. Workers also were queried about use in high noise areas on their most recent job site and the previous job site. Self-report is a reliable way to measure use of hearing protection (Lusk, Ronis, & Baer, 1995b) In the study of factory workers, three indicators of use were evaluated: self-report, observation, and supervisor report. There were several reasons why those findings supported self-report as the method of choice to determine use: (a) a high correlation of self-report and observed use (r=.89); (b) a small mean difference between self-reported use and observed use (within 5% of each other for 56% of the workers and within 10% of each other for 71% of the workers); (c) the high cost of conducting observations; and (d) the limited proportion of the total period of time that can be observed (Lusk, Ronis, & Baer, 1995b). In addition, the possibility of overestimation of use was deemed to be even less a factor for construction workers than for factory workers as they do not yet have OSHA-mandated (1981) nor workplace rules regarding use of hearing protection, as do factory workers (Lusk, Ronis, & Hogan, 1997).

Table 2: HPM Concepts, Scales, and Reliabilities

HPM Component	Scale	Description	Range	M	theta
Interpersonal Influences	Norms	4 items[b]	1-3	2.2	.76
	Support	12 items[b,c]	1-3	1.5	.85
	Modeling	2 items[b]	1-3	2.4	.86
Situational Factors	Availability/Access to HP	9 items	1-5.4	3.1	.81
	Noise exposure	3 items[d]	1-100	46.8	.94
Perceived control of health	Health competency	8 items	1.4-6	3.1	.79
Definition of health	Health conception – Clinical	7 items	1-6	5.0	.87
	Health conception – Overall wellness	9 items	1.3-6	4.9	.87
Perceived health	Self-rated health	4 items[b]	1.3-3.3	2.5	.70
Perceived self-efficacy	Self efficacy in use of HP	10 items	1.5-6	4.4	.78
Perceived benefits	Benefits of HP	12 items	2.4-6	4.6	.73
	Value of use of HP	6 items	1-4	2.6	.88
Perceived barriers	Barriers to use of HP	12 items	1-5.6	3.0	.83

[a]All items, except where noted, had a 6-point Likert scale. [B]Items with 3 or 4 response categories, [c]Eight of the items in this scale were used in the analyses. [D]Percent of time exposed to high noise during three time periods, past week, past month, past 3 months.

Findings

Description of Samples

There were significant differences in demographics, noise and hearing loss variables, noise exposure, and use of HPDs among the trade groups in the regional sample. **Tables 3, 4 and 5** present those results, along with characteristics of the national sample.

The data in these tables were compiled from the Phase 3 posttest measures. Phase 1 data is reported in the *in press* manuscript in the AIHA Journal.

Table 3: Demographics by Trade Group - Phase 3 Posttest

	Regional						National	
	Carpenters (N=208)		Operating Engineers (N-356)		Plumber/Pipefitters (N=234)		Plumber/Pipefitters (N=230)	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age*	26.9	5.7	44.3	8.8	30.9	7.2	41.9	7.3
Yrs. In Trade*	4.2	3.6	20.3	8.8	5.6	5.3	19.9	7.5
Yrs. As Apprentice*	2.8	1.0	1.2	2.1	3.4	2.0	4.4	0.8
Variable	N	%	N	%	N	%	N	%
Gender Male	200	97	349	99	221	95	218	97
Ethnicity White	174	86	316	93	213	92	213	95
Black	18	9	11	3	9	4	4	2

*Significantly different among three trade groups in regional sample.

Education	N	%	N	%	N	%	N	%
8th Grade	----	----	14	4	--	--	--	--
High School (HS)	117	57	263	74	92	40	49	21
HS & Trade School	52	25	40	11	63	27	94	41
Assoc. Degree (AD)	14	7	12	3	22	10	6	3
Trade School (TS)	12	6	16	5	27	12	39	17
AD + TS	5	2	4	1	19	8	27	12
Bach. of Sci. (BS)	2	1	7	2	7	3	8	4
AD + BS	2	1	----	----	1	0.4	--	--
Graduate Degree	2	1	----	----	--	--	1	0.4

Table4: Noise & Hearing Loss Variables - Phase 3 Posttest

	Regional						National	
	Carpenters (N=208)		Operating Engineers (N=356)		Plumber/Pipefitters (N=234)		Plumber/Pipefitters (N=230)	
Variable	N	%	N	%	N	%	N	%
Perceived Hearing Loss*	113	55	260	74	136	59	172	76
Hearing Test*	137	66	280	80	187	81	165	73
Hearing Loss on Test*	17	13	150	55	41	24	76	47
Ever Use HP*	123	60	306	87	200	89	214	94
Noise at Recent Job	127	64	242	75	140	62	127	60

* Significantly different among three trade groups in regional sample.

Table 5: Noise Exposure and use of hearing protection - Phase 3 Posttest

	Regioinal				National
	Carpenters (n=208)	Operating Engineers (n=356)	Plumber/ pipefitters (n=234)		Plumber/ pipefitters (N=230)
Noise Exposure	N %	N %	N %		N %
At last jobsite	127 (63.5)	242 (74.7)	140 (62.2)		127 (59.6)
At job before	102 (51.8)	218 (70.8)	117 (53.4)		115 (54.5)
Past week	94 (48.0)	32 (36.9)	107 (48.6)		65 (31.0)
Past month	121 (62.4)	43 (49.8)	158 (72.5)		130 (62.2)
Past 3 months	144 (75.0)	213 (70.3)	161 (77.0)		151 (72.9)
Use of Hearing Protection	Mean (SD)	Mean (SD)	Mean (SD)	F	Mean (SD)
At last job site	34.4 (24.6)	65.4 (35.6)	41.5 (34.3)	48.02**	50.9 (35.9)
At job before	34.8 (34.1)	66.8 (35.2)	46.3 (33.7)	33.39**	51.5 (35.8)
Past week	32.9 (35.6)	50.4 (40.9)	36.7 (35.9)	7.96*	36.9 (38.1)
Past month	33.2 (33.3)	54.6 (39.1)	41.8 (33.0)	14.70**	54.8 (33.9)
Past 3 months	35.5 (33.3)	57.6 (36.4)	41.3 (31.5)	23.65**	55.5 (33.5)
Mean use for 3 time periods	35.6 (33.9)	56.7 (40.9)	40.9 (31.9)	2.30**	50.4 (34.0)
Mean use for all 5 measures	36.1 (33.0)	61.3 (34.2)	42.6 (31.8)	38.16**	49.9 (36.6)

p< .001, ** p< . 0001

Results in regard to each aim are presented in the following pages.

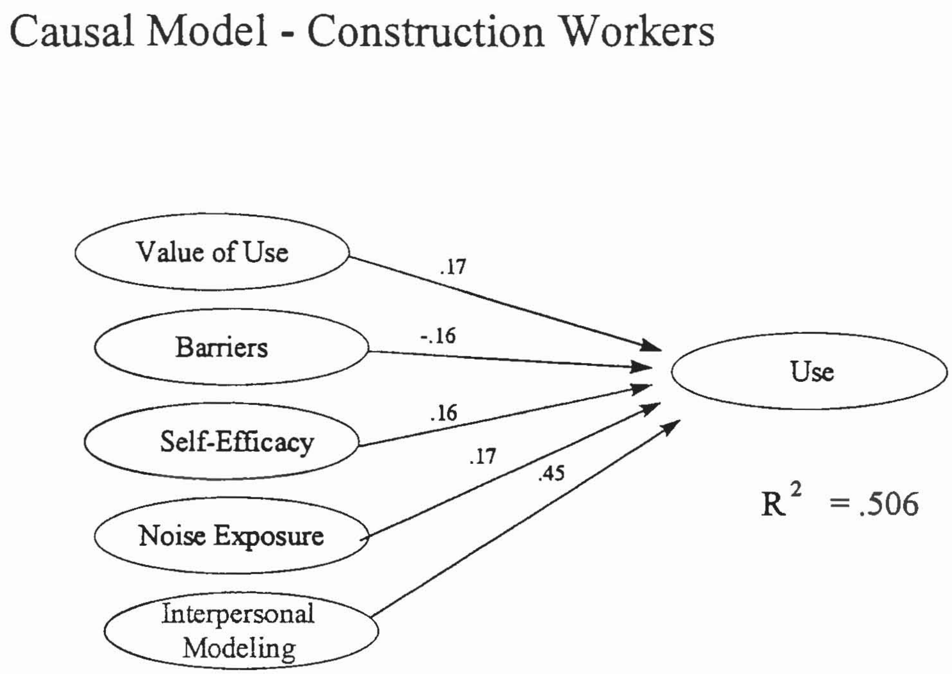
Aim 1:

Identify the most important predictors of construction workers' use of hearing protection, specifically for carpenters, plumber/pipefitters, and operating engineers.

Regional Sample

Tests of the health promotion model (HPM) as a causal model of the regional sample of construction workers' use of hearing protection (n=359), resulted in models that fit the data well. The theoretical model accounted for 36.3% of the variance, and the exploratory model accounted for 50.6% of the variance in use of hearing protection. Barriers to use, value of use (which measured benefits of using hearing protection), and self-efficacy were significant predictors in the theoretical and exploratory models. Perceived health status was a predictor in the theoretical model alone. Two modifying factors, noise exposure and interpersonal influences-modeling, were significant predictors in the exploratory model where modifying factors were allowed direct relationships with hearing protection use. Modifying factors exerted direct effects on behavior, with the strongest effects on the behavior resulting from variables specific to the behavior measured by the dependent variable (use of hearing protection). Clearly the HPM was useful in predicting construction workers' use of hearing protection. As an example, exploratory model results are depicted in **Figure 2.**

Figure 2: Exploratory Health Promotion Model



These results are presented in detail in the publication regarding the test of the causal model (Lusk, Ronis, & Hogan, 1997)

National Sample

Using stepwise regression with the national sample (n=144), the HPM accounted for 36% (Adjusted R^2 = .34) of the variance in use of HPDs with situational factors, interpersonal factors-modeling, health conception, and value of use as the significant predictors.

Thus, there was consistency between the regional samples of construction workers and national samples of plumber/pipefitter trainers in the importance of interpersonal factors-modeling and value of use. Situational factors, important for the plumber/pipefitter trainers, was not a significant factor for the total construction worker group, and barriers to use, important for the regional group of construction workers, was not a significant factor for the plumber/pipefitter trainers. A health variable, either health conception or health status achieved significance for both groups in one of the models.

Aim 2

Use the identified predictors of construction workers' use of hearing protection to adapt the training program already developed for factory workers, to the needs of construction workers.

The identified predictors (described in Specific Aim 1) were used as the bases for the information in the training program. The following process, described in detail in the submitted manuscript (Lusk, Kerr, Ronis, & Eakin, 1997), was used to translate the predictors from the theoretical model into an intervention. Each item in the scales measuring these predictors was examined by trade group. Three criteria were used for selection of items to guide content of the training program: 1) those items which correlated with use of HPDs (.20 or higher); 2) those items with room for improvement in scores not already at ceiling; 3) those items with potential for change. Items were retained if these criteria were met by one or more of the three trade groups. After these criteria were met, two scripts based on the most important predictors (utilizing the items which met the criteria) and on social learning theory (Bandura 1986) were written for a videotape and for trainers to use in guiding the sessions.

Although it was originally planned to use video footage from the factory worker videotape, it was decided that it would not be as meaningful for construction workers. Therefore, all video footage used in this project was new. Shots were selected to incorporate construction worker activities and sites into the final product. Professional actors were hired to fulfill the roles in the video. Based upon feedback from consultants to the project and workers who pilot tested the training program, revisions were made in the program, including shooting additional video. The effect of this revised training program was then assessed as specified in Aim 3.

Aim 3

Assess the effect of the training program on construction workers' use of hearing protection.

Regional Sample

Mean self-reported posttest (T2) use of HPDs was the same (carpenters) or higher (operating engineers and plumber/pipefitters) than pretest (T1) use for all trade groups (**Table 6**). It was expected that pretest use and pretest intention to use would be fairly strongly associated with posttest use. With the exception of the regional plumber/pipefitters pretest intention to use and posttest use, these measures were significantly correlated for all groups **(Table 7)**. These correlations were not as large as might have been expected, e.g., the maximum variance in posttest use accounted for by pretest use was 15% (carpenters).

A significant effect of the intervention was found only in the plumber/pipefitter trade group. As can be seen in **Table 8**, there were no significant effects of the pretest or of the combination of the pretest and posttest on posttest use. Changes in plumber/pipefitter mean use is presented in **Table 9**.

Pretest use and pretest intention to use were significant covariates of posttest use for this group (**Table 10**).

Table 6: Mean and Standard Deviations of Percent of Use of HPDs Before (T1) and After (T2) Intervention.

	Regional									National		
	Carpenters			Operating Engineers			Plumber/Pipefitters			Plumber/Pipefitters		
	n	T1	T2	n	T1	T2	n	T1	T2	n	T1	T2
Pretest Only	46	33 (30)	40 (33)	75	59 (33)	57 (33)	49	40 (34)	37 (27)	29	47 (34)	40 (32)
Pretest & Inter-vention	31	45 (37)	45 (38)	66	54 (32)	58 (34)	62	37 (34)	50* (32)	43	40 (36)	57* (32)

* Significantly different from T1 mean use

Table 7: Correlation of Pretest Use and Pretest Intention to Use with Postest Use

	Trade Group	Pretest Use	Pretest Intention
Regional	Operating Engineers	.33*** (n=141)	.31*** (n=154)
	Carpenters	.39*** (n=77)	.23* (n=80)
	Plumber/Pipefitters	.28 ** (n=111)	.18 (n=119)
National	Plumber/Pipefitters	.33** (n=74)	.23* (n=89)

* p< .05, ** p< .01, *** p< .001

Table 8: Analysis of Variance of Posttest Mean Use of HPDs: Plumber/Pipefitters

Sources	Mean Square	df	F	P
Pretest (P) vs Not	110.80	1	.12	.73
Intervention (I) vs Not	11389.70	1	12.70	.001
P X I	0.00	1	0.00	1.00
Error	898.8	106		

Group	n	Mean	SD
Pretest Only	51	37.1	26.5
Pretest + Intervention	69	49.5	32.1
Intervention Only	42	48.6	32.7
Control	45	32.5	32.8
Total	207	42.6	31.8

Table 9: Comparison of Pre and Posttest Mean Use of HPDs: Regional Plumber/Pipefitters and National Plumber/Pipefitters

Regional Plumber/Pipefitter	Pretest Mean	Postest Mean	Change*	Change as % of base
Pretest Only (n=49)	40	37	-3	-8
Pretest and Intervention (n=62)	37	50	+13	+35
National Plumber/Pipefitter				
Pretest only (n=29)	47	40	-7	-15
Pretest and Intervention (n=45)	40	57	+17	+43

* Change = T2-T1

Table 10: Analysis of Variance of Posttest Use with Pretest Intention and Pretest Use as Covariates: Plumber/Pipefitters

Sources	Mean Square	df	F	P
Covariate: Pretest Intention	4792.75	1	5.51	.021
Main Effect of Intervention	5804.60	1	6.68	.011
Error	868.90	116		
Covariate: Pretest Use	8589.38	1	10.51	.002
Main Effect of Intervention	4684.16	1	5.73	.018
Error	817.19	108		

National Sample

Results similar to those for the regional plumber/pipefitter group were found for the national sample of plumber/pipefitter trainers. The significant intervention effect was demonstrated only in regard to their use of HPDs at their most recent job, rather than for the sum of use for all time periods (**Table 11**).

Table 11: Analysis of Variance of Posttest Use of HPDs at Post Recent Job Site: Plumber/Pipefitter Trainers

Sources	Mean Square	df	F	P
Pretest (P) vs Not	3339.85	1	3.70	.058
Intervention (I) vs Not	10742.89	1	11.91	.001
P X I	152.47	1	.169	.682
Error	902.36	79		

Group	N	Mean	SD
Pretest Only	26	33.4	28.3
Pretest + Intervention	35	63.6	32.9
Intervention Only	42	58.3	37.4
Control	35	42.4	35.8
Total	138	50.9	35.9

Summary of Findings

The most important results from the analyses in this project are:

- construction workers' self-reported use of HPDs is entirely inadequate to prevent NIHL;
- the three trade groups studied significantly differed on a number of factors;
- the HPM predicted a large amount of the variance in construction workers' use of HPDs;
- pretest use and pretest intention to use HPDs were significantly correlated with posttest use for the 4 samples, with one exception: the regional plumber/pipefitters pretest intention to use was not significantly correlated with posttest use;
- the predictor-based training program was effective in significantly increasing plumber/pipefitters' and plumber/pipefitter trainers' use of HPDs. Pretest use and pretest intention to use were significant covariates;
- reasons for the non-significant effect of the intervention on two trade groups (carpenters and operating engineers) are not readily apparent from the data;
- pretest measurement of use of HPDs and predictors of use of HPDs did not have an effect on the impact of the training.

Aim 4

Revise the training program as indicated, and make it available for general use with construction workers.

Based upon feedback from subjects and project consultants, a training manual has been written, the videotape and brochures revised, and the package is being prepared for national distribution. At the time the grant was written, a non-profit educational materials distributing group expressed interest in being a distributor, but they have since determined it does not fit with their product lines. Negotiations are under way with seven other possible distributors, two of them national professional associations.

The goal of the distribution is to insure the program's availability for use in training construction workers. Therefore, the desired outcome is an effective marketing and distribution plan. Consistent with the original grant proposal, any royalties which accrue to the University will be used to update the training materials.

Excerpts from this training program will also be used by Dr. Kerr, University of Minnesota, Principal-Investigator of a newly funded NIOSH grant to develop and test an interactive, tailored intervention for construction workers.

Conclusions

The conceptually based intervention developed and tested in this project was effective in increasing HPD use in two of the four samples. Further study is needed to determine how to increase HPD use by the other two trade groups (carpenters and operating engineers) included in the study. It is expected that the use of individually tailored training may be more effective with all construction workers and this is being tested in a new study with Dr. Madeleine Kerr as Principal Investigator and Dr. Sally Lusk as Co-Principal Investigator.

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*The copies of published and in press articles are attached.