Effectiveness of Training and Reinforcement on HPD Use Among Construction Workers

Noah Seixas, PhD – Principal Investigator
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Background and study overview

High noise levels are ubiquitous in the construction industry. As a result, although it is completely preventable, noise induced hearing loss (NIHL) is very common among construction workers. Factors such as intermittent and highly variable noise levels, lax regulatory enforcement, lack of awareness and knowledge of harmful noise levels, attitudes and beliefs towards using hearing protection devices (HPDs) and the improper use of HPDs contribute to construction workers' NIHL.

To evaluate the effectiveness of different strategies to increase use of HPDs among construction workers, we designed and implemented a large-scale four year long study (July 2005 – May 2009) across eight construction sites in the Puget Sound area. The aims of this study were to assess the effectiveness of a three-component intervention in motivating construction workers to effectively wear HPDs during periods of high noise exposure. HPD use was captured via two self-reported instruments, a questionnaire and a validated combination of task card (including HPD use) with simultaneous dosimetry measurements. All study methods and protocols were approved by the University of Washington Institutional Review Board (IRB).

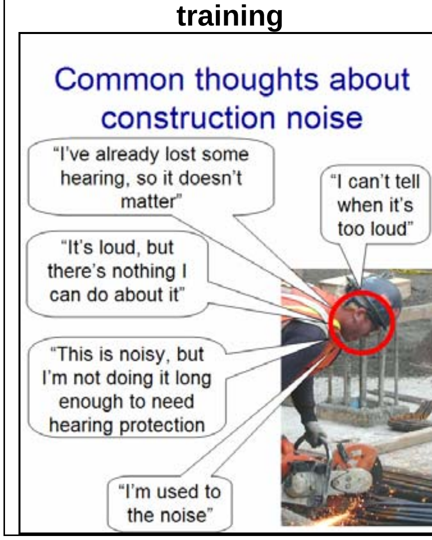
Study design and development

The study consisted of three interventions:

1. A one-hour long hearing conservation training,
2. Use of an innovative new noise level indicator (NLI), and
3. Follow-up reinforcement tool-box trainings (TB).

Hearing Conservation Intervention: The content of the one-hour long hearing conservation training was intended to address common barriers to HPD use, and was guided by a modified version of Pender's Health Promotion Model (HPM). The HPM has previously been shown to predict construction workers' use of hearing protection (Lusk et al, 1997). Training concepts were specifically matched to the constructs of the modified HPM along with meeting OSHA training requirements. Eight constructs in total were covered in the training and incorporated five belief factors (perceived susceptibility, severity, benefits, barriers, and self-efficacy), two HPD use cofactors (interpersonal norms and situational influences), and one knowledge factor. The training incorporated two "hands-on" demonstrations, including instruction on the selection and proper use of HPDs and teach-back elements for trainees to respond to questions and real-life experiences. For maximum flexibility, the training was designed to be delivered as either a one-time 1 hour session or two 30-minute segments, and used flip chart visual materials (see example in Figure 1) for logistical

Figure 1: Example materials from hearing conservation training



ease. Additionally, the design of the training delivery was intended for peer trainers, or trainers trained by an expert, to be able to give the training as effectively as an expert.

Development and Testing of Training Program

We conducted a pilot test of the hearing conservation training was done on one construction site with 23 workers (Neitzel et al, 2008). HPD use increased significantly post-training, with the percent of time that HPD worn in noise levels above 85 dBA nearly doubling. However, there were virtually no statistically significant differences seen in survey responses in relation to the survey items. The results of this pilot demonstrated the potential short-term effectiveness of the training program.

We also tested the flexibility of the training delivery by comparing the effectiveness of the training when delivered by an expert versus a trainer who had been trained in a "train-the trainer" program (Trabeau et al, 2008). One-hundred and three workers were trained by four trainers who had received the "Train-the-trainer" training (n=56 workers), and one expert trainer (n=45 workers). Effectiveness was assessed by comparing pre- and post-training changes in beliefs regarding HPD use, knowledge of noise, and self-reported HPD use in high noise. There were no statistically significant differences found between the expert and the train-the-trainer groups except for two belief items, one pertaining to susceptibility and the other pertaining to self-efficacy. As a result, we believe the training program could be used in a 'train-the-trainer' mode, assuming the trainers receive appropriate guidance and instruction on the use of the materials. The images used for the training are available at:

Figure 2: Noise level indicator

Noise Level Indicator

The NLI used in the study was a prototype, smaller than a cell phone, which provided real-time noise levels to construction workers by flashing different colored lights and vibrating at noise levels at or above 85 dBA (see Figure 2). The unit was designed to be worn on workers' lapel or fall protection harness for maximum visibility.

Figure 3: Example toolbox training materials

Toolbox Trainings

Additionally, Toolbox (TB) trainings were given every other week for two months (four TB trainings total per worker). Each of the four TB trainings was 5 minutes long and covered a single key topic from the hearing conservation training (see example in Figure 3). Intervention activities on each site started with the one-time hearing conservation training but lasted two months with the additional NLI intervention(for some subjects) and TB interventions (for some sites).

Intervention evaluation measures

Evaluation components of the interventions included a survey given at four different time periods, the assessment of worker's shift noise exposure using data-logging dosimeters, and task cards reporting HPD use during the shift in which noise levels were measured at three different time periods. The survey had sections covering the beliefs associated with the HPM model constructs listed above, as well as current and intended use of HPDs. The percent of time during a shift which equivalent continuous sound pressure levels (e.g., Leq levels, measured according to the NIOSH Recommended Exposure Limit, or REL, for noise) exceeded 85 dBA was calculated using the dosimetry data and matched with when a worker reported wearing HPDs from the associated task card.

Prior to intervention activities (e.g., the baseline time period), study participants received a survey and one exposure assessment with a matching task card indicating HPD use. Immediately following the training, participants completed another survey. Once all of the intervention activities were completed (two months after training), all participants regardless of the intervention group completed another survey and an exposure assessment with a matching task card indicating HPD use. Finally, a follow-up exposure assessment with activity card and a survey occurred four months after training.

Site and participant allocation to intervention groups

All participants across the eight participating construction sites received the one-hour hearing conservation training. Four of the sites received no additional training while the other fours sites received the bi-weekly TB training. Workers from all eight sites were randomized into two groups, those who received NLI and those who did not. In total, there were four different intervention groups: those who received the training only, those who received the training and NLI, those who received the training and TB, and those who received all three, training, NLI and TB. All participants provided informed consent with a form approved by the University of Washington IRB prior to enrolling in the study.

<u>Results and key findings</u>

Participants

Two hundred seventy-one construction workers (roughly thirty to forty construction workers per site) were enrolled into the study. The trades represented in the study were carpenters, laborers, electricians, iron workers, operating engineers, sheet metal workers, plumbers, pipefitters and cement masons. Ninety-seven percent of the subjects were male and on average were 37.7 years old. Sixty-three percent of the subjects had a high school education level and 30% had more than a high school education. The most common trade group was carpenters which made up 43% of the subjects, with laborers (17%) and electricians (11%) being the other largest represented trades. A few differences were seen in the demographic data between the four intervention groups with TB sites reporting slightly better hearing and less years working in construction.

Noise exposures

Our study documented exposures among the participating construction workers which routinely exceeded the NIOSH REL of 85 dBA. The mean full-shift Leq level prior to intervention activities was 89 $\pm$ 5 dBA, with an average of 40 $\pm$ 20% of time in each shift spent above 85 dBA . Average noise levels dropped slightly at the two and four month follow-up, though both were still above 85 dBA (88 $\pm$ 5 dBA and 87 $\pm$ 5 dBA, respectively, and about 33% of each shift spent over 85 dBA on average).

HPD use

We found that self-reported HPD use was found to be more accurate from task cards than from surveys; HPD use was typically overstated via survey (Trabeau et al, 2008; Edelson et al, 2009). As a result, we used HPD use from the task card method as the primary outcome measure for the intervention. A clear bi-modal distribution of HPD use was seen from the task card data. At baseline, eighty-one percent of subjects reported using HPDs either almost always (>90% of time >85 dBA) or almost never (<10% of time >85 dBA).

We have restricted the HPD use data analyses presented here to the 176 construction workers who completed exposure assessments in all three time periods of the study (at baseline, at the end of the two-month intervention period, and at a 4-month follow-up). Table 1 shows HPD use at the three time periods. Overall, the percent of time HPDs were used in high noise increased from 35% pre-intervention to almost 50% at the end of the 2-month intervention period. At the four month follow-up, HPD use was just over 40%. A statistically significant increase in HPD during both intervention follow-up periods, compared to pre-intervention levels, were observed.

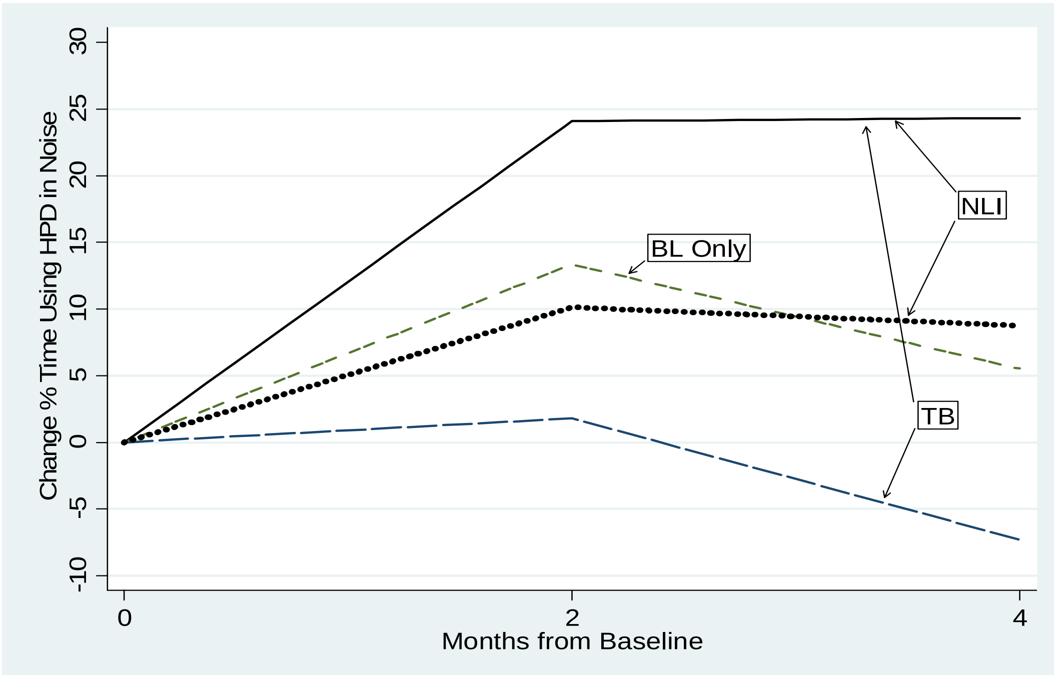
Table 1. Percent time HPD used prior to intervention and change in percent at 2 and 4-month follow-up by intervention group

		Pre-Intervention	**2-Month Follow-up**		**4-Month Follow-up**	
	N	Using HPDs	Using HPDs	Change from Baseline#	Using HPDs	Change from Baseline#
% of time HPD used		Mean (SD)	Mean (SD)	Mean (SD)	Mean(SD)	Mean(SD)
All Groups	176	34.5 (42.8)	46.7 (43.8)	12.1 (46.3)**	42.0 (43.6)	7.5 (46.5) †
BL Only	46	30.0 (40.1)	43.3 (43.3)	13.4 (44.8) †	35.5 (41.1)	5.5 (40.9)
BL and Toolbox	44	48.5 (46.9)	50.3 (44.5)	1.8 (48.8)	41.2 (43.8)	-7.3 (54.8)
BL and NLI	45	33.7 (43.3)	43.8 (44.4)	10.1 (40.3) ‡	42.4 (44.3)	8.8 (37.6)
BL, Toolbox, NLI	41	25.5 (38.3)	49.6 (44.1)	24.1 (49.9)*	49.8 (45.5)	24.3 (7.4)*

#Tests for change: t-test for change in % of time: ‡ $p<0.1$, † $p<0.05$, * $p<0.01$, ** $p<0.001$.

Figure 4 shows the change in percent of time HPDs were used by intervention group during the three assessed time periods. All four groups improved their HPD use at two months post-intervention. Statistically significant changes were seen in HPD use from pre-intervention to both the 2-month and 4-month follow-ups for the intervention group that had all three interventions (training, TB and NLI). This was the only group that sustained significant positive changes for the duration of the follow-up periods. Additionally Figure 1 shows that although the group receiving BL and TB with time has a negative percent change in HPD use, this group had the highest pre-intervention HPD use.

Figure 4. Change in percent of time workers used HPDs at two-month (end of intervention period) and four-month assessments by intervention group.



Workers who reported using HPDs greater than 50% of the time in high noise at baseline were much more likely to continue using them in the follow-up period. A linear regression model using HPD as a continuous variable and including only the intervention group as a predictor of change resulted in the full intervention group (BL, NLI, and TB) having a roughly 25% increase in HPD use on average.

HPM results

HPM results from surveys given in the pilot test of the hearing conservation training, and in the baseline exposure assessment for the intervention, indicated that the HPM constructs performed poorly in explaining HPD use among the participating workers (Trabeau et al, 2008; Edelson et al, 2009). The only constructs that were found to relate to HPD use were two items, one addressing barriers to use of HPDs, and the second to self-efficacy of HPD use. This finding does not support previous research (Lusk et al, 1997) using the HPM. This discrepancy may be at least partially due to the more accurate task card-based HPD assessment strategy used in the current study. Results from pre and post intervention analysis showed that, in general, workers with low HPM related scores prior to the intervention were more likely to adopt HPD use during the study.

At a group level, high safety and HPD climate increased the odds of HPD use prior to intervention activities, implying that management support for safe work practices is important in influencing use of hearing protection. However, after intervention activities, those reporting a more positive climate were less likely to change HPD use after the intervention. This might be due to the fact that participants at the sites with positive safety climates were already using HPDs regularly.

Conclusions

The hearing conservation training program we developed for construction workers was found to result in increased HPD use among participating workers The flexibility of the training was also demonstrated through the similar results in training delivered by either experts or trainers having undergone a "train-the-trainer" program. Although the training contents were developed using the HPM, the measurements of the HPM constructs in the survey did not indicate improvements in any of the constructs following training. Our study also documented that workers' self-report of HPD use is more accurate when measured via task card than via survey, and that a positive HPD and safety climate appear to promote HPD use.

The training was successful at increasing use of HPDs over the course of the study. The initial increase in HPD use at two months post-training was reduced at the four month post-training evaluation, but still statistically significant. The only intervention group that sustained significant positive changes for the duration of the follow-up periods was the group that received all three interventions (training, subsequent toolbox training, and use of the noise level indicator). These findings suggest that future interventions designed to increase use of hearing protection among construction workers would benefit from the use of a multi-prong intervention strategy, and that a small noise level indicator, which provides real-time feedback to the worker may significantly contribute to worker's using HPDs in a sustained fashion. However, even with such interventions many workers will require additional interventions to protect them from noise exposures.

For further information and full description of the study and its findings see:

Neitzel R, Meischke H, Daniell W, Trabeau M, Somers S, Seixas N. Development and pilot test of hearing conservation training for construction workers. Am J Ind Med 51(2): 120-129 (2008). PMID: 18067178.

Trabeau M, Neitzel R, Meischke H, Daniell W, Seixas N. A comparison of 'train-the-trainer' vs. expert training modalities for hearing protection use in construction. Am J Ind Med 51(2): 130-137 (2008). PMID: 18067179.

Edelson J, Neitzel R, Daniell W, Sheppard L, Stover B, Seixas N. Predictors of hearing protection use in construction workers. Ann Occup Hyg 53(6): 605–615 (2009). PMCID 2732185.

Seixas NS, Neitzel R, Stover B, Sheppard L, Daniell WE, Edelson J, Meischke H. A multi-component intervention to promote hearing protector use among construction workers. Int J Audiol (Submitted May 2010).

and access to the training materials may be found at the following URLs:

One-hour hearing conservation training package:
http://staff.washington.edu/rneitzel/hc_training.pdf

Toolbox training materials:
http://staff.washington.edu/rneitzel/hc_toolbox.pdf

References

Edelson J, Neitzel R, Daniell W, Sheppard L, Stover B, Seixas N. Predictors of hearing protection use in construction workers. Ann Occup Hyg 53(6): 605–615 (2009). PMCID 2732185.

Griffin S, Neitzel R, Daniell W, Seixas N. Indicators of hearing protection use: self-report and researcher observation. J Occup Environ Hyg (6): 639–647 (2009). PMID: 19626532.

Lusk S, Ronis D, Hogan M. Test of the Health Promotion Model as a causal model of construction workers' use of hearing protection. Research in Nursing and Health. 1997;20:183-94.

Neitzel R, Meischke H, Daniell W, Trabeau M, Somers S, Seixas N. Development and pilot test of hearing conservation training for construction workers. Am J Ind Med 51(2): 120-129 (2008). PMID: 18067178.

Seixas NS, Neitzel R, Stover B, Sheppard L, Daniell WE, Edelson J, Meischke H. A multi-component intervention to promote hearing protector use among construction workers. Int J Audiol (Submitted May 2010).

Trabeau M, Neitzel R, Meischke H, Daniell W, Seixas N. A comparison of ‘train-the-trainer’ vs. expert training modalities for hearing protection use in construction. Am J Ind Med 51(2): 130-137 (2008). PMID: 18067179.

Chronological List of Student Theses and Dissertations Completed During This Study

Trabeau, M. An evaluation of "train-the-trainer" vs. expert training modalities for hearing protection use in construction. University of Washington Department of Environmental and Occupational Health Sciences, 2006.

Woodruff, J. Validation of task-based noise exposure predictions in the construction trades. University of Washington Department of Environmental and Occupational Health Sciences, 2006.

Griffin, S. Indicators of hearing protection use : self-report and researcher observation. University of Washington Department of Environmental and Occupational Health Sciences, 2007.

Neitzel, R. Improving estimates of occupational noise exposure. University of Washington Department of Environmental and Occupational Health Sciences, 2009.