Hearing Screening Program Impact on Noise Reduction Strategies

D. C. Voaklander, R. C. Franklin, K. Challinor, J. Depczynski, L. J. Fragar

ABSTRACT. *The objective of this study was to determine the impact of the New South Wales Rural Hearing Conservation Program on the implementation of personal hearing protection (PHP) and noise management strategies among farmers who had participated in this program in New South Wales, Australia. A follow-up survey of a random sample of people screened through the New South Wales Rural Hearing Conservation Program was linked to their baseline data. The use of PHP at baseline was compared to use at follow-up in four specific scenarios: use with non-cabbed tractors, with chainsaws, with firearms, and in workshops. For non-cabbed tractors, the net gain in PHP use was 13.3%; the net gain was 20.8% for chainsaws, 6.7% for firearms, and 21.3% for workshops. Older farmers and those with a family history of hearing loss were less likely to maintain or improve PHP use. Those with severe hearing loss, males, and participants reporting hearing problems in situations where background noise was present were more likely to maintain or improve PHP use. Forty-one percent of farmers had initiated other strategies to reduce noise exposure beyond the use of PHP, which included engineering, maintenance, and noise avoidance solutions. The early (hopefully) identification of hearing deficit in farmers and farm workers can help promote behavior change and help reinforce a farm culture that supports hearing conservation. The continuation and expansion of hearing screening programs such as these should be encouraged as basic public health strategy in farming communities.*

Keywords. *Agricultural, Farmers, Farm safety, Hearing health, Noise abatement, Noise injury, Program evaluation.*

Research in noise-induced hearing loss (noise injury) has been intermittent, and only in the last two decades have efforts been made to measure the consequences of long-term exposure to noise in the agricultural population (Glorig, 1957; Townsend et al., 1975; Thelin et al., 1983; Broste et al., 1989; Marvel et al., 1991; Eddington et al., 1995; Solecki, 1998; Day et al., 1999; Karlsmose et al., 2000;

Submitted for review in October 2007 as manuscript number JASH 7233; approved for publication by the Journal of Agricultural Safety and Health of ASABE in February 2009.

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  ISSN 1074-7583

Solecki, 2002; Williams et al., 2002; Solecki, 2003). Studies examining the consequences of noise exposure among farmers have consistently reported that farmers are a high-risk group for noise injury. The hearing loss observed in farmers is significantly greater than what would be expected by age alone (Marvel et al., 1991; Day et al., 1999; Williams et al., 2002; Karlovich et al., 1988). The hearing loss is greater for males than for females, and the left ear is usually affected more than the right (Marvel et al., 1991; Karlsmose et al., 2000). It has been shown that hearing loss begins at an early age, with farm children exposed to high noise levels when helping with farm tasks (Broste et al., 1989; Solecki, 1998; Challinor, 2000).

The implementation of personal hearing protection (PHP) by farmers has also lagged behind other high-noise industries. However, there has been some improvement in this area. Karlovich et al. (1988) reported that less than 20% of farmers from Wisconsin consistently used PHP. Challinor and Coleman (1995) reported New South Wales (NSW), Australia, data that suggested an increase of 10% between 1991 and 1994 in the usage of PHP among farmers exposed to non-cabbed tractors. Day et al. (1999) reported that 90% of Victoria, Australia, farmers owned PHP devices, but only 43% of them used the devices frequently. In New Zealand, McBride et al. (2003) found that up to 43% of farmers used PHP, but use depended on the type of activity. Use of chainsaws (43%) saw the greatest frequency of PHP use, while tractors with cabs saw the lowest frequency of PHP use (14%). Recently, Kerr et al. (2003) reported that in industries such as agriculture where there is no workplace screening, programmatic screening for hearing loss should be established.

Few evaluations of interventions to increase the use of hearing protection have been conducted. One study evaluated a school-based hearing conservation program (Knobloch and Broste, 1998). At the program's conclusion 87% of the intervention students reported using PHP at least some of the time, compared to 45% of the control students. Knobloch (1999) evaluated another school-based program to increase the use of PHP. Post-program, 80% of parents of the intervention group intended to use PHP, compared to 68% in the control group. There have been no published studies of the effects of a hearing screening program on the implementation of PHP. The objective of this study was to determine the impact of a hearing screening and information program on the implementation and use of PHP in a farm population in Australia.

Materials and Methods

The Program

The NSW Rural Hearing Conservation Program (NSW RHCP) has been offered to farm communities since the mid-1980s. In its current format, it has been operating since 1992. In excess of 6000 hearing screenings and information sessions have been provided to rural farmers and their families since the program's inception. Rural people traditionally access less health services than their urban counterparts (Strong et al., 1998) and have a lower use of screening programs utilized by urban populations (Gourlay and Robinson, 1995). Thus, the program was designed to provide hearing screening for farm families through field days and agricultural shows that are held throughout NSW. By having the program available to farm families during "down time," the participation is greatly increased. The results of the screening are discussed with participants, and recommendations are made, where necessary, to help farmers and their families reduce their exposure to high noise levels. The NSW RHCP defined normal hearing as hearing thresholds between 0 and 20 decibels hearing level (dBHL), mild noise-induced hearing loss (NIHL) between 20 and 40 dBHL, moderate NIHL between 40 and 60 dBHL, and severe NIHL between 60 and 80 dBHL. To differentiate between an NIHL and other hearing loss, an NIHL was determined as a hearing loss that showed a typical deterioration in hearing thresholds at 3000, 4000, or 6000 Hz with improvement at either 6000 or 8000 Hz.

To determine if the NSW RHCP had an impact on noise exposure reduction, a mail survey was sent as a quality assurance follow-up to persons in contact with the program during the years 1995 through 2001. Data from returned surveys were linked to original data collected at the time of program contact. Ethics approval for this study was obtained from the New South Wales Department of Health Ethics Committee.

Sampling

A random sample of 1000 participants was selected from the master database of all persons utilizing the program between 1995 and 2001. The total number of participants during that time was 5013.

The Dillman method for mail surveys (Dillman, 2000) was used to maximize survey returns. All those selected received a post card announcing the study one week prior to the first survey mail-out. One week following the first survey mail out, a postcard was sent to all recipients of the first survey thanking them for their participation and encouraging those who had not done so to fill out and return their surveys. Two weeks following the first survey mail-out, a second survey was mailed out to all those who had not yet responded with a letter encouraging to take the time to fill out the survey. Prior to the survey being mailed out, a reference group of farmers was asked to pilot the questionnaire and give feedback to project staff.

Questionnaire

To facilitate comparison with baseline data, a questionnaire was developed that asked identical questions about PHP to those that were asked at hearing screening. In addition, an open-ended question asked farmers what strategies they had implemented to prevent hearing loss on the farm since their exposure to the hearing screening program. This questionnaire was pilot-tested with a group of 20 NSW farmers who suggested minor wording and terminology changes.

Analyses

Descriptive analyses using frequencies, means, and standard deviations (SD) are presented. Bivariate and multivariable stepwise logistic regression were used to determine characteristics of farmers who improved or maintained their use of PHP compared to farmers who reported reducing their use of PHP or never using PHP. The unadjusted odds ratios represent the univariate comparison of characteristics associated with PHP use, while the adjusted odds ratio variables related to the implementation of PHP represent the unique contribution of each variable controlling for other variables in the model. All variables significant at $p < 0.10$ were entered into the stepwise elimination process. An odds ratio less than one indicates that a characteristic is related to a smaller likelihood of PHP implementation, while an odds ratio in excess of one indicates a characteristic that is related to a greater likelihood of PHP implementation. Thematic analysis of the open-ended question regarding noise reduction strategies was also conducted.

Results

Subjects

Between 1995 and 2001, the screening program tabulated data for 5013 individuals who were screened at farm field days and who resided in NSW. A total of 1000 individuals who had gone through the hearing screening program were selected by random sampling. Of these, 15 were either duplicate individuals or did not have complete addresses. Out of the 985 follow-up questionnaires sent out, 97 were returned without being opened. This gave a contact rate of 90%. Of the 888 remaining eligible questionnaires, 565 were returned, giving a response rate of 64%. Table 1 depicts differences between respondents and non-respondents to the survey. Non-respondents were more likely to be female, were significantly younger, had farmed fewer years, and were less likely to be suffering from a hearing deficit. Twenty-two percent (n = 124) of respondents indicated they were no longer farming. Those who ceased farming between screening and follow-up were significantly older than those still farming and non-respondents, perhaps indicating some level of natural retirement from active farming. All subsequent results relate to those who indicated that they were still actively involved in farm activities (n = 441).

Implementation of Personal Hearing Protection

Program participants were asked in the follow-up interview to report in which situations they used personal hearing protection (PHP). Table 2 outlines in which situations the use of PHP improved after contact with the screening program. For non-cabbed tractors, the net gain in PHP use was 13.3%; the net gain was 20.8% for chainsaws, 6.7% for firearms, and 21.3% for workshops. At the initial screening, 22.9% of individuals stated that they never used hearing protection in any situation. At follow-up this figure had fallen to 13.2%.

Table 3 describes the results of the logistic regression analysis. Column 1 indicates that a number of variables were significantly related to the implementation /use of PHP at the univariate level. Variables associated with increased PHP use included male gender, having difficulty hearing the TV or in situations with background noise, having tinnitus, and severe hearing loss. Variables associated with decreased PHP use

Table 1. Characteristics of respondents and non-respondents.

	Respondents (n = 565)					
Baseline Characteristic	Still Farming (n = 441)		No Longer Farming (n = 124)		Non-Respondents (n = 323)	
	Mean	SD	Mean	SD	Mean	SD
Age at screening (years)	44.7	14.3	52.4	17.1	37.9*	16.0
Years farming (years)	22.3	14.5	25.6	17.2	15.8*	13.0
Time since screened (years)	3.7	1.9	3.8	1.7	3.8	1.8
	No.	%	No.	%	No.	%
Male	373	85	96	77	253	78*
Normal hearing in right ear	102	23	23	19	104	32*
Normal hearing in left ear	98	22	12	10	95	29*
Family history of hearing loss	46	12	11	10	26	9

* $p < 0.05$.

Table 2. Use of personal hearing protection at follow-up.

Situation	Net gain in PHP Use (%)	Baseline "Always Use" (%)	Frequency of use increased or stayed at "Always Use" (%)	Frequency of use stayed at "Sometimes" (%)	Frequency of use decreased or stayed at "Never Use" (%)	Baseline "Never Use" (%)
Non-cabbed tractors	13.3	30.8	44.1	21.4	34.5	42.9
Chainsaws	20.8	38.0	58.8	14.6	26.6	42.2
Firearms	6.7	17.3	24.0	51.2	24.8	66.8
Workshops	21.3	19.6	40.9	15.7	43.4	56.5

All changes $p < 0.05$.

included having a family history of hearing loss and years involved in agriculture. Referring to column 3, the adjusted model in which all significant characteristics were controlled for, older farmers were 2% less likely to maintain or increase their use of PHP for every year of increasing age, In addition, those with a family history of hearing loss were 49% less likely to maintain or increase their use of PHP. Males were approximately 500% more likely to maintain or improve their use of PHP compared to females. Those with severe hearing loss were about five times more likely to maintain or increase the use of PHP, while respondents reporting that background noise interfered with their hearing were twice as likely to improve or maintain their use of PHP.

Noise Reduction Strategies Reported by Farmers

Table 4 illustrates the types of noise reduction and management strategies reported by the participants. The vast majority of farmers responding to this question reported that PHP provision and awareness activities were used to reduce noise exposure. Other strategies included improved maintenance of equipment, limiting noise exposure, and modification of the work area. Forty-one percent of farmers had initiated strategies to reduce noise exposure beyond the use of PHP alone.

Table 3. Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) for characteristics related to the improvement and maintenance of PHP use.

Baseline Characteristic		Unadjusted Odds Ratio (95% CI)	Adjusted[a] Odds Ratio (95% CI)
Age		0.99 (0.99,1.00)	**0.98 (0.98,0.99)**
Gender (male)		**3.92 (2.94,5.24)**	**5.98 (4.30,8.30)**
Years involved in agriculture		**0.98 (0.98,0.99)**	
Family history of hearing loss		**0.73 (0.55,0.98)**	**0.57 (0.41,0.78)**
Hearing difficulty watching TV		**1.38 (1.13,1.68)**	
Hearing difficulty using the telephone		1.00 (0.80,1.25)	
Hearing difficulty during conversation or at meetings		0.95 (0.78,1.16)	
Hearing difficulty in work environment		1.04 (0.84,1.29)	
Hearing difficulty with background noise		**1.69 (1.34,2.14)**	**2.09 (1.59,2.73)**
Has tinnitus		**1.50 (1.23,1.84)**	
Hearing loss:	Normal	1.00	1.00
	Mild NIHL	1.19 (0.91,1.58)	1.19 (0.88,1.60)
	Moderate NIHL	1.01 (0.71,1.44)	1.25 (0.85,1.84)
	Severe NIHL	**3.34 (1.72,6.49)**	**4.80 (2.42,9.51)**
	Profound NIHL	0.92 (0.54,1.58)	1.58 (0.88,2.84)
Years since screened		1.05 (0.97,1.23)	1.14 (1.04,1.23)

[a] For all variables in the model (only statistically significant variables shown).

Table 4. Frequency of strategies mentioned in open ended question about strategies to reduce noise exposure.

Strategy	Frequency of Response[a]
Hearing protection – increased awareness, use, accessibility, quality	481
Improved equipment maintenance (e.g., repaired mufflers)	63
Limitation of exposure to noise	48
Purchased quieter equipment	34
Re-arranged work area	19
Avoidance of noise	15
Warning signs/awareness training	7

[a] Does not sum to 441 as some farmers had undertaken more than one noise reduction strategy.

Discussion

These results indicate that the NSW RHCP had an impact on farmers' hearing conservation behavior. Improvement in the use of PHP ranged from 6.7% during the use of firearms to 21.3% in workshop environments. In addition, 41% of farmers had initiated strategies to reduce noise exposure beyond the use of PHP, which included engineering, maintenance, and noise avoidance solutions.

Factors Related to PHP Use

Characteristics related to the use of PHP post-program were male gender, the presence of tinnitus, having a severe noise-induced hearing loss, and years since screened. Farm females have been found to have less hearing loss than equivalent farm males (Karlsmose et al., 2000; Karlovich et al., 1988). The lower implementation of PHP among women may be related to exposure, where female farmers may be less likely to participate in noise-creating tasks. This lower exposure level may influence women's behavior in choosing PHP, as its routine use may not be established in the same manner as for males. In industrial settings where work tasks are similar, gender does not appear to affect the rate of PHP use (Lusk, 1997). There is some concern, however, that gender differences in farm noise exposure are changing, with more females involved in the farm workplace due to broader economic and workforce supply factors.

Individuals who were suffering the consequences of noise exposure (tinnitus and severe noise-induced hearing loss) were also more likely to use PHP at the time of the follow-up survey. Perceived susceptibility has been found to positively influence PHP use in other industries (Melamed et al., 1996). Those who have been noticeably affected by noise damage may be more inclined to want to preserve what hearing capacity remains.

Unlike many health promotion activities, field day hearing screening appears to have more of an effect on participant's behavior as time extends from field day contact. It may take extended periods of time to make recommended changes on farms regarding noise reduction and the use of PHP. Costs would be a factor, so a slow phasing in of hearing conservation strategies likely occurs.

Factors negatively associated with the implementation of PHP included age and a family history of hearing loss. Among blue collar workers, increasing age has been found to negatively affect PHP use (Lusk, 1997). Older farmers may be less inclined to adopt new practices than younger farmers or may question the efficacy of PHP use.

Hearing loss in a farm family may be considered one of the inevitable risks of farm life. This may be particularly true if children have grown up with parents who are suffering from a significant hearing loss. Findings from Appalachian Mountain coal workers, who in many cases are multigenerational miners, suggest a willingness to accept the inevitability of hearing loss as part of the risk of being a miner (Patel et al., 2001). This type of view may be similar for other multigenerational industries, such as farming.

Noise Reduction Strategies Reported by Farmers

The vast majority of comments reported by farmers regarding noise reduction strategies were about the provision and accessibility of PHP on farms. In the hierarchy of injury control strategies (Haddon, 1995), the use of personal protective equipment is the lowest. However, for most farmers, it would be perceived as the lowest-cost alternative. About 41% of the respondents reported more sophisticated strategies than enhanced PHP use. These strategies included equipment modification or purchase, and reduced exposure to excess noise. Comparative data on other strategies for hearing conservation on farms have not been widely studied; however, a recent research article reported that farmers from the northeastern U.S. used alternative strategies to PHP use 13% of the time (Jenkins et al., 2007).

Limitations

There are several limitations that need to be highlighted regarding this evaluation. The first and perhaps most important is that this particular study design did not control for other concurrent programs or public service campaigns designed to improve hearing conservation behavior in NSW farmers or for any general trends that might encourage healthy behaviors over time. However, to our knowledge, there were no organized broad-based programs conducted that were focused on farmers and hearing conservation during the years covered by this project, nor wider programs in rural NSW.

Another limitation is that there are significant differences between respondents and non-respondents with regard to age, farming experience, and hearing loss. As all of these variables in this study were related to the use/implementation of PHP, the estimates reported here may be somewhat biased and can only be generalized to our final sample. However, because older age, more farming experience, and history of hearing loss are related to lower rates of PHP use, it is likely that PHP use after the screening program is higher than the estimates reported here due to a greater response rate among individuals with these negatively correlated attributes.

Notwithstanding these limitations, we attempted to minimize variability by matching individuals' baseline characteristics to their follow-up surveys. This would lower the variability associated with measuring different groups of individuals at two points in time. Finally, using a systematic data collection approach, the response rate reached an acceptable 64%.

Study Implications

This follow-up of the participants of the NSW RHCP indicates that there is value in offering hearing screening to farm families in Australia if for no other reason than to monitor hearing conservation on Australian farms. The early (hopefully) identification of hearing deficit in farm workers (particularly those who are younger) can help promote behavior change and help reinforce a farm culture that supports hearing conservation. The continuation and expansion of hearing screening programs such as these should be encouraged as basic public health strategy in farming communities.

Conclusion

Farmers reported using a variety of interventions to reduce noise exposure on their farms. This study supports the view that hearing screening programs may provide important information to farmers wishing to adopt noise reduction strategies on farms. However, hearing conservation strategies appear to be used less by older farmers and by farmers with a family history of hearing loss. The use of field day hearing screening programs can be an effective way to increase awareness of noise injury among farmers.

Acknowledgements

This study was funded by a grant from New South Wales Health. The funding body had no role in the study design, data collection, analyses, or interpretation of the data.

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