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Farm Noise Emissions During Common Agricultural Activities

J. Depczynski, R. C. Franklin, K. Challinor, W. Williams, L. J. Fragar

ABSTRACT. *Noise injury in agriculture is a significant yet often unrecognized problem. Many farmers, farm workers, and family members are exposed to noise levels above recommended levels and have greater hearing loss than their non-farming contemporaries. The aim of this study was to gather up-to-date information on farm noise levels and to enhance the quality of information available to assist farmers in reducing noise exposure and meeting Occupational Health and Safety (OHS) regulations regarding noise management. Farm visits were conducted on 48 agricultural establishments that produce a range of commodities. Noise levels were measured at the ears of operators and bystanders involved in typical activities on farms. The average and peak noise levels were measured for 56 types of machinery or sites of farming activity, totaling 298 separate items and activities. Common noise hazards identified included firearms, tractors without cabs, workshop tools, small motors (e.g., chainsaws, augers, pumps), manual handling of pigs, shearing sheds, older cabbed tractors, and heavy machinery such as harvesters, bulldozers, and cotton module presses. We found that use of firearms without hearing protection presents a pressing hearing health priority. However, farming activities involving machinery used for prolonged periods also present significant risks to farmers' hearing health. Noise management strategies on the farm are essential in order to prevent noise injury among farmers.*

Keywords. *Farmers, Farm machinery, Farm worker, Hearing, Noise, Tractor.*

Noise injury is a significant problem in the Australian farming community. Two-thirds of over 6,000 farmers screened at field days through the NSW Rural Noise Injury Prevention Program showed signs of noise injury on audiograms (Challinor et al., 2000), with hearing loss evident even among young farmers (Franklin et al., 2002). International studies also report a high prevalence of hearing loss among farmers (Karvolich et al., 1988; May et al., 1990; Plakke and Dare, 1992). A South Australian farm noise exposure study found that farmers' hearing ability was on average equivalent to that of people who were 15 years older in the general Australian population; that is, the hearing sensitivity of a 40 year old farmer was similar to the hearing sensitivity of a 55 year old person in the general community (Williams et al., 2002).

Evidence from agricultural hearing programs across Australia indicates that hearing damage is due to the prolonged exposure to on-farm noise hazards such as tractors, chainsaws, and firearms (Challinor et al., 2000; Williams et al., 2002). Exposure to noise

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levels of more than 85 dB(A) for more than 8 h a day (or its sound energy equivalent) on a regular basis can cause permanent hearing damage (ISO, 1990). Noise level data from other studies have confirmed that tractors and farm implements generate noise levels above recommended daily durations (May et al., 1990; Holt et al., 1993; Dennis and May, 1995). Damage to hearing can be caused by prolonged and cumulative effects of noise over many years, which results in metabolic damage to the cochlea, or by acoustic trauma associated with peak noise levels over 140 dB, which results in instantaneous damage to hearing structures (Clark and Bohne, 1999).

Noise injury can have disabling personal and social consequences for the affected persons and their families. Those affected by noise injury may need to turn up the volume on the television, may not hear the telephone, may frequently ask for words to be repeated, may not reply when called from a distance, and may have difficulty hearing conversation in social settings (Williams et al., 2002).

Persons with hearing loss sometimes limit verbal interactions due to frequent misunderstandings and embarrassment (Dugan and Kivett, 1994). The increased effort required to follow conversation can lead to fatigue, anxiety, and stress (Williams et al., 2002). The effects of hearing loss may be increased in rural areas where access to health services is often limited (McKellan, 1995). Persons with occupational hearing loss have also been shown to be at increased risk for further occupational injury as a result of their sensory impairment (Zwerling et al., 1998).

The national standards on occupational noise management in Australia are outlined by the National Occupational Health and Safety Commission (NOHSC, 2000a). These standards state that the duration for occupational noise exposure over an 8 h working day is an A-weighted average noise level of 85 dB(A) [L_{Aeq8h} = 85 dB(A)] or equivalent, with peak C-weighted noise level duration at 140 dB(C) [L_{Cpk} = 140 dB(C)]. It should be noted that farmers rarely limit their work day to the common industrial 8 h shift. Increasing this to a 16 h workday would reduce L_{eq} to 82 dB(A), assuming the 3 dB exchange rate advocated by NOHSC. Weightings refer to the instrumentation scale used.

Each state in Australia has developed a set of Occupational Health and Safety (OHS) regulations and codes of practice to guide noise management and foster compliance with noise durations specified in its legislation. The legislation in each state varies slightly; however, all of them are based on the NOHSC guidelines. Farmers are required to comply with all state OHS regulations in Australia. In recent years, Australian OHS regulations have adopted a risk management approach as opposed to the previous more prescriptive approaches. Risk management allows more flexibility with OHS solutions in that they can be more easily adapted to the type of work place, frequency of occurrence of the activity or process, number of individuals, and the resources available.

This project aimed to gather up-to-date information on noise levels of common agricultural equipment within the farming context. The information will be used particularly to assist hearing health professionals provide quality information in discussions with farmers at field day hearing screening programs. Guidance material produced from the data will assist farmers in their decisions about noise control, exposure times, and selection of appropriate hearing protection and ensure that they are able to meet their requirements under state Occupational Health and Safety Acts and Regulations.

Methodology

Noise levels at the ear of the operator and others working in the vicinity (bystanders) were measured during engagement in common agricultural activities. Ethical permission for this study was obtained from the New England Area Health Services Human Ethics Committee.

A snowball sampling method was used to access farmers representing a variety of production systems from northern New South Wales and southern Queensland (table 1). Initial contacts were made through existing networks, such as regionally based Farm Safety Action Groups, producer representatives, and word of mouth. Advertisements in local newspapers were also used to try to engage farmers, but they did not yield a response.

The field researchers included a clinical nurse consultant (CNC) nurse audiometrist (RN, BA, Dip. Occ. Health and Safety) with over 20 years experience in researching noise-injured farmers; and a research assistant employed for the project (RN, Grad. Cert. Adv. Nurs. (rural and remote), MN, BSc, Grad. Dip. Ed.) with workplace audiometry training. An acoustics engineer from the National Acoustic Laboratories trained the field researchers to conduct field noise assessments using an integrating sound level meter per Australian / New Zealand Standard 1269.1 (1998) and Australian Standard 2659.1 (1988).

A recently calibrated CEL 440 integrating sound level meter (type 1) was used for the project, fitted with a QE4146 microphone and 1/1 octave filter. A windscreen was used at all times with a 0.5 in. free-field microphone. Procedures for measuring farm noise were in accordance with Australian / New Zealand Standard 1269.1 (1998) and Australian Standard 1259.2 (1990).

The farm visit collected information about noise exposure on a standard questionnaire that:

- Identified major noise risks on the farm (in consultation with the farmer).
- Measured noise levels at the ear of the operator (and others) of key noise hazards with the calibrated noise level meter.
- Obtained the amount of time the farmer spent in a particular activity (this information varied from activity to activity (i.e., for some activities, such as using the grinder to fix a gate, the response may have been an hour a day, while driving a tractor may have been 15 h per day during harvest and 4 h per day during the rest of the year).
- Identified the commodities produced on the farm.

Average (L_{Aeq}) and peak (L_{Peak}) noise levels (in dB) of the machine in were measured within 10 cm of the ear (closest to the noise source) of operators and others working in the vicinity. Due to the variable operating conditions and nature of the agricultural workplace, other workers were often in the general vicinity rather than at a specific location. A typical position of a bystander was taken as the noise measurement point for “others.” Where bystanders were not available on the day of measurement, an approximate position of their ears during the activity, as advised by the farmer, was identified and taken as the measurement point. The distance of the bystander from the noise source was recorded. Measurements of noise levels from each machine were made while it was idling and again under working or simulated working conditions. Additional measurements were taken where other conditions were met (for example, while the machine was traveling). Only the measurements taken when the machine was working were used for analysis.

Noise measurements were all taken under mild weather conditions, with minimal wind. The measurement period was typically 20 to 30 seconds for stable noise, or several minutes for less constant noise. Operating conditions were measured for each farm activity and machine. The upper sound level duration of the instrument was 140 dB (i.e., above 140 dB, the sound level meter did not record the sound accurately); levels of

144 dB indicated when the sound level was beyond the instrument's range. All sound was integrated into the sound level meter.

Noise level data were entered into Microsoft Access and analyzed using SPSS. The identity of individual farmers was not linked to the pooled data. Descriptive statistics on range and central tendencies were obtained for average and peak noise emissions for each machinery type.

Recommended exposure durations when engaged in an activity without the use of hearing protection were calculated, based on the average noise level received at the ear for each activity. A 3 dB exchange rate was used, i.e., for each 3 dB increase in noise level, the sound energy received at the ear is doubled, so that for every 3 dB above the recommended daily exposure of 85 dB(A), the time exposed to the noise needs to be halved to remain within recommended exposure durations. This method of estimating recommended exposure durations is commonly used in OHS and hearing health promotion programs (Karvolich et al., 1988) and is explained further in the national standards and codes of practice relating to noise and noise management (Plakke and Dare, 1992; NOHSC, 2000a; Australian Standard 2659.1, 1988).

The results were interpreted on-site for the farmer. Noise levels and recommended exposure duration were explained. Other recommendations as appropriate regarding farm noise, noise reduction strategies, and hearing protection were also provided.

Results

A total of 48 farms were visited over a three-month period from late February to mid-May 2002. Types and locations of farms are summarized in table 1.

Fifty-six different types of machinery or activity were identified in the survey. There were 385 noise measurements recorded, of which 327 were at the operator's position and 58 were at bystander's positions. Common noise hazards identified included firearms, tractors without cabs (i.e., un-cabbed), workshop tools, small motors (e.g., chainsaws, augers, pumps), manually feeding and handling pigs, shearing sheds, and heavy field machinery (e.g., cabbed tractors, harvesters, and cotton module presses) (fig. 1).

The noise levels for the study sample were normally distributed, with the majority of the "noisy" equipment operated in the region of 85 dB(A) to less than 95 dB(A). Because the meter used in this study was unable to record over 140 dB, reported noise levels of firearms should be regarded as an underestimate.

Table 1. Classification of farms by commodity group and geographical region.

Commodity Group	No. of Farms	Geographical Region	No. of Farms
Dairy	5	New South Wales	
Grains only	3	North coast	5
Horticulture	8	Northern tablelands	7
Mixed grains / cotton	8	Northwest slopes	10
Mixed grains / livestock	11	Northwest plains	19
Piggeries	2	Queensland	
Poultry and/or eggs	1	Darling downs	3
Sheep and/or cattle	8	Lockyer valley	4
Sugar	2		
Total	48	Total	48

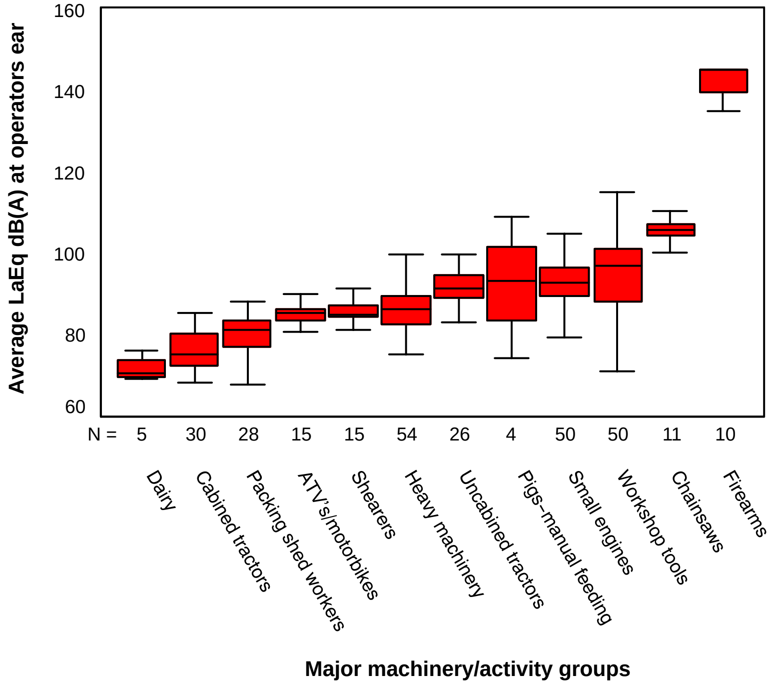

Figure 1. Mean A-weighted noise levels, 95% confidence intervals, and ranges of aggregated machinery and activity groups while working at the operator's ear.

Average Noise Levels for Major Machinery and Activity Types

Average noise levels at the operator's ear and at the bystander's ear during working conditions are represented in table 2 and table 3, respectively, for selected machinery and activity types. Recommended exposure durations when using specific machinery without the use of hearing protection are also shown, using the 3 dB exchange rate as described.

The relatively small sample size of some types of equipment and the wide variability in similar types of equipment resulted in a wide range in noise level around the mean (fig. 1). This is particularly evident for pig sheds where manual feeding occurred and pigs were being handled. Piggeries with automatic feeders and minimal handling (i.e., feedlot piggeries with no breeding) were relatively quiet, with noise levels averaging 70 dB(A) (n = 6 recorded positions, L_{Aeq} mean = 72 dB(A), median = 72 dB, SD = 5, minimum = 67 dB, maximum = 80 dB, and L_{Peak} = 104 dB). Note that the autofeeding piggery is not included in figure 1.

Initial attempts were made to use the exposure information provided by the farmers to develop a typical daily noise dose picture, similar to Dennis and May (1995); however, no typical day adequately explained all the possible activities that a farmer undertakes. Thus, it was decided to only look at exposure by activity or equipment (as seen in tables 2 and 3) and thus enable farmers to build a day around the activities they would undertake.

Table 2. Average noise levels and recommended exposure durations for operators for common farm machinery and activities on 48 Australian farms.

Machinery or worker position during normal operating conditions (No. of machines or activity sites)	Sample size (recorded positions)	Noise level at operator's ear, average (range) (95% CI) L_{Aeq}, dB(A)	Recommended exposure durations without hearing protection[a]
Air compressors (10)	10	86 (77 - 95)	7 h (15 min - 8+ h)
All terrain vehicles (13)	13	86 (84 - 87)	7 h (4 - 8 h)
Angle grinders (12)	12	98 (96 - 100)	20 min (15 - 30 min)
Augers (12)	12	93 (89 - 96)	1 h (30 min - 3 h)
Bench grinders (6)	6	99 (94 - 104)	18 min (5 min - 1 h)
Bulldozers (6)	6	99 (97 - 100)	18 min (15 - 30 min)
Chainsaws (11)	11	106 (104 - 107)	3 min (2 - 5 min)
Circular saws (12)	12	99 (98 - 101)	18 min (10 - 20 min)
Cotton module presses (14)	14	86 (85 - 88)	6 h (4 - 8 h)
Cotton pickers (6)	6	81 (78 - 85)	8 h (8 - 8+ h)
Avg. increase with radio on (4)	4	1 - 3 dB	4 h - 8+ h
Dairies (5) - 24-bay herringbone pit	10	73 (71 - 75)	No limit
Farm trucks (11)	11	85 (83 - 88)	8 h (4 - 8 h)
Firearms (10)	10	L_{Peak} 140+ dB	No exposure
Forklifts (4)	4	84 (81 - 88)	8 h (4 - 8 h)
Harvesters (7)	7	83 (75 - 91)	8 h (2 - 8+ h)
Avg. increase with radio on (2)	2	2 - 5 dB	40 min - 8+ h
Irrigation pumps (7)	7	100 (96 - 104)	15 min (5 - 30 min)
Motorbikes - 2 wheel (2)	2	81 (70 - 92)	8 h (1.5 - 8+ h)
Packing sheds (6)	28	80 (78 - 82)	8 h+ (8 - 8+ h)
Pig handling - suckers (1)	1	109	1 - 2 min
Pig sheds - manual feeding (3)	3	87 (74 - 99)	5 h (15 min - 8+ h)
Shearing sheds (6) - shearers	15	86 (84 - 87)	7 h (4 - 8 h)
Sugarcane harvester (1)	1	86	7 h
Avg. increase with radio on (1)	1	2	4 h
Tractors with cabs (30)	30	76 (75 - 78)	No limit
Tractors with cabs 10+ years (8)	8	81 (77 - 84)	8 h (8 - 8+ h)
Avg. increase with radio on (22)	22	3 - 5 dB	4 - 8+ h
Tractors without cabs (26)	26	92 (90 - 93)	1.5 (1 - 2) h

[a] Noise exposure risk for each activity in the day is cumulative toward the overall noise exposure risk. For example, if exposed to a noisy activity for half the recommended daily duration (e.g., angle grinder for 10 min of a 20 min daily duration), any remaining noise exposure in the day should not exceed half the recommended daily duration for another activity (e.g., a duration of 4 h instead of 8 h on a tractor with a radio).

Bystanders in the Workplace and Factors Influencing Noise Level

The average noise levels experienced by other people working in the vicinity are presented in table 3. A number of factors were examined for their influence on the noise level at the ear of the operator and bystander, including variable operating conditions (e.g., idle vs. working speed, secondary implements), age of machinery, radios, cabs, and long operating hours. These factors can affect noise levels and therefore influence recommended exposure times, choice of strategies to reduce noise, and the use of hearing protection. The factors that affect noise emission level are described further in Depczynski et al. (in press).

Table 3. Average noise levels and recommended exposure durations for bystanders for common farm machinery and activities on 48 Australian farms.

Machinery or worker position during normal operating conditions (No. of machines or activity sites)	Sample size (recorded positions)	Average distance from noise source	Noise level at bystander's ear, avg. (range) (95% CI) L_{Aeq}, dB(A)	Recommended exposure durations without hearing protection[a]
Angle grinders (6)	6	3.3	90 (87 - 93)	2 h (1 - 5 h)
Bench grinders (5)	5	4.5	89 (82 -96)	3 h (40 min - 8 h)
Chainsaws (6)	6	2.8	96 (93 - 99)	40 min (15 - 50 min)
Circular saws (11)	11	3.7	89 (84 - 94)	3 h (1 - 8 h)
Cotton module presses (14) - rakers	23	3.5	84 (82 - 86)	8 h (6 - 8 h)
Cotton pickers (2)				
Servicing heads (picker idling)	4	2.3	83 (77 - 89)	8 h (4 - 8+ h)
End of row (picker turning)	2		94	1h
Harvesters (1)	2	10.0	90	2 h
Shearing sheds (7) - shed assistants	11	2.7	80 (77 - 83)	8 h+ (8 - 8+ h)
Tractors with cabs (6)	9	3.0	85 (80 - 90)	8 h (2 - 8+ h)
Tractors without cabs (10)	13	3.0	82 (78 - 86)	8 h (6 - 8+ h)

[a] Noise exposure risk for each activity in the day is cumulative toward the overall noise exposure risk. For example, if exposed to a noisy activity for half the recommended daily duration, any remaining noise exposure in the day should not exceed half the recommended daily duration for another activity.

Discussion

Noise levels and time of exposure are significant issues on Australian farms; however, with the use of appropriate noise control measures, protection strategies, or changes in practices, noise exposure can be significantly reduced.

Pig sheds are an excellent example of how changes in farm practices and design (i.e., automatic instead of manual feeding) can significantly reduce the amount of noise that farmers are exposed to. It was observed that feedlot piggeries with automatic feeders avoid arousal of the pigs, and noise levels are much lower than in sheds where manual feeding occurred. The upper range of measurements (table 1) is more typical when pigs were being manually fed or handled, and hearing protection is required for these activities. Noise exposure to bystanders, particularly in workshop situations, can be reduced by undertaking the task outside where there is less reverberation.

The highest exposure level measured on the farms was related to firearms, which are capable of causing instant damage to hearing structures. This is a serious risk for both the shooter and anyone in close proximity (including children). The comparative sound energy emitted by a single shot from a firearm at 140 dB is equivalent to almost a full week of continuous exposure at 90 dB(A) (Clark, 2002). A single shot without hearing protection exceeds occupational health and safety regulatory standards. Young farmers and others who regularly engage in on-farm recreational shooting, including those who accompany shooters, are particularly at risk. Wearing suitable hearing protection when using firearms is a must and should be the highest priority in health promotion interventions among farmers using firearms.

Chainsaws noise levels were found to be similar to that found by Dennis and May (1995). Other small motors, such as augers and pumps, also have high noise levels and are significant noise hazards on farms, even when used for a short period of time. There are also machines with comparatively low levels of noise that present a significant noise hazard because they are used regularly or for extended periods of time, such as tractors without cabs.

A chainsaw operating at 106 dB(A) is significantly louder than a tractor at 91 dB(A), and the chainsaw operator is perhaps more likely to take precautions such as wearing hearing protection. The longer period of use for the tractor, however, makes the tractor a greater potential noise hazard than the chainsaw even though it is less noisy. Greater awareness of this concept needs to be promoted, particularly considering that there are more "moderately noisy" machines (i.e., 85 to 95 dB) than "very noisy" machines (+95 dB).

Long-term, unprotected exposure to a variety of on-farm noise hazards places farmers at real risk of noise injury. Noise reduction strategies and use of hearing protection should be employed in all farm environments where it is necessary to raise one's voice to be heard by another person at a distance of 1 m (3 ft) or less.

A hierarchical control approach of reducing noise at the source and during transmission wherever possible should also be considered. Noise hazards on the farm are best addressed within a comprehensive OHS approach to hazard identification, risk assessment, and control. Noise control measures suggested at Australian field day hearing screening programs (Williams et al., 2002; Clark 2002) and codes of practice (NOHSC, 2000b), which include machinery substitution and engineering controls, are appropriate for reducing exposure to noise. These practices include:

- Buying newer, quieter machinery.
- Modifying the design of work areas and machines.
- Using tractors or other machines with a cab (particularly new ones, as they are noise rated).
- Using insulating materials around motors and equipment.
- Modifying work practices to avoid noise where possible.
- Performing regular maintenance.
- Rotating farm tasks.

Examples of these strategies were observed on the farms visited in this study. For example, a number of farmers had relocated their workbenches closer to the opening of their worksheds so that noise was better dissipated. Another made a point of using a cabbed tractor in preference to an uncabbed one for tasks longer than half an hour. Several farmers stated that assistants and bystanders stood well away from machines such as augers and post-drivers, if not required for the task at hand, thereby avoiding noise. Noise barriers and insulating materials were often used in packing sheds to separate workers from dryers and other equipment. Personal hearing protectors were usually on hand, and should always be available in addition to, rather than instead of, these higher-order controls.

A fact sheet and a guidance pamphlet were produced using the noise level data from this study, including the recommended exposure durations for different farm activities. This information has been incorporated into a fact sheet and used by hearing health practitioners in discussions with farmers. The fact sheet is available at: www.a-cahs.med.usyd.edu.au/nfidc/noise_exposure.htm for farmers to access at home.

Limitations

Sampling: A snowball sampling method was used due to time and cost limitations on the project and because of difficulty accessing farmers through print media and self-engagement. Accessing farmers through farm safety action groups may have resulted in the recruitment of more safety-conscious farmers and thus introduced some level of bias that was not controlled. However, assuming that involvement in a safety action group translates to greater awareness and practice of noise management and safety behaviors on the farm, any bias present would likely be in favor of reduced noise levels at the ear of the operator and others, due to machinery maintenance regimes and better position of workers in relation to noise barriers and insulation.

Measurement: The timing of the project meant that some types of machinery in common use at other times of the year were not available for measurement (e.g., many grain harvesters were in sheds and non-operational). When other persons were present in the workplace, they were often transitory or in the general vicinity rather than at a specific location. This means that, unlike the usually exact position of an operator, the noise exposure of another worker was at an approximate location, within a variance of a few meters, depending on the advice provided by the farmer. In addition, the sound level meter did not accurately measure noises above 140 dB, and in some cases, the actual noise level may have been higher than reported. While sound levels were measured within 10 cm of the listener's ear, the effects of head/body shadow may not have been closely recorded. Any such variations would represent only minor changes in the overall results. An ear-mounted microphone could be used for future studies and more accurate work; however, this increase in precision is easily lost among other measurement inaccuracies.

Analysis: There were relatively low numbers for some types of machinery and activities on the farms visited. This may have resulted in high variability around the mean noise level for some activities (table 1). Variance was a particular problem for piggeries, harvesters, and air compressors, due to some machines creating large amounts of noise. There was also a wide range of similar types of machinery that varied by age, manufacturer, horsepower, condition, and power source, which would be factors in the amount of noise produced. This effect could be minimized in future studies, given larger sample sizes and differentiating further between categories.

Conclusion

This project aimed to identify current noise hazards in the farm workplace and improve the quality of information available to farmers, particularly in the advice given to farmers at field day hearing screening programs. The information collected will enable farmers to better recognize noise hazards on the farm and point to appropriate strategies required to meet OHS obligations regarding noise. Based on the exposure levels in this study, the most prominent risk to farmers' hearing was firearms. However, most farm activities involving machinery resulted in noise levels that presented significant risks to hearing function if unprotected exposure was sustained for extended durations. This highlights the importance of noise management strategies on the farm to reduce the incidence and harmful effects of noise injury. A practical guidance tool has been produced from the data to assist farmers in making better decisions regarding noise management on the farm.

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