

Original Research

Farmers' work-day noise exposure

Warwick Williams, PhD,¹ Susan Brumby, PhD,^{2,3} Adrian Calvano, (NIL),² Tracey Hatherell, (NIL),² Heidi Mason, (NIL),² Cate Mercer-Grant, (NIL),² and Anthony Hogan, PhD⁴

¹National Acoustic Laboratories, Sydney, New South Wales, ²School of Medicine, National Centre for Farmer Health, Deakin University, ³Western District Health Service, Hamilton, Victoria and ⁴Institute for Governance and Policy Analysis, University of Canberra, Canberra, Australian Capital Territory, Australia

Abstract

Objective: This study aims to understand the extent of farmers' exposure to hazardous noise, and trial and test the ability of an on-farm noise audit report to improve awareness and preventative action towards farm based noise hazards.

Design: Visits were made to working farms where noise and dosimetry measurements undertaken. During return visits, the noise measurements were explained in a brief report. A follow-up questionnaire was implemented gathering feedback on the use or otherwise of the report.

Setting: Working farms in Western Victoria and SE Queensland including dairy, beef, wool, prime lamb and cropping.

Participants: Participants were 14 female and 37 male farm workers.

Interventions: Noise exposure assessment of daily activities through dosimetry; measurements of noisy tasks and machinery; supply and interpretation of a noise audit report.

Main outcome measures: Participants were supplied with a 'noise report' of their workplace together with an explanation of the report's meaning to farm workers.

Results: Men and women have similar at risk exposures. The average noise exposure was 1.09 Pa²h ($L_{Aeq,8h} = 85.3$ dB). This implies 163 000 Australian agricultural workers are at risk from hazardous noise. On-farm noise audit reports were a relevant and valuable feedback to farmers in relation to their potential noise hazards.

Conclusions: Of those measured 51%, and by extrapolation 163 000 Australian agricultural workers, have

noise exposure levels greater than the recommended Australian Standard of 1.01 Pa²h (85 dB). Men and women are equally exposed. On-farm noise audit reports are an effective feedback to increase awareness and improve hearing health.

KEY WORDS: farm noise, hearing loss, noise management, on-farm noise audit.

Introduction

Noise at work in agriculture will cause hearing loss.¹ There are many different sources of noise on farms, such as tractors, workshop tools, livestock, heavy machinery and firearms. Noise can be a safety hazard at work, interfering with communication and making warnings difficult to hear. There are also the insidious background noises to which farmers are regularly exposed, such as livestock activity, pigs squealing, pumps, shearing and milking machinery. Damage to hearing will be caused by the prolonged and cumulative effect of exposure to excessive noise over many years, or by instant acoustic trauma associated with peak noise levels such as the use of shotguns.² What is unclear from current research is evidence of the typical noise exposure of farm workers, high or low, and/or how many individuals are involved.

Access Economics reports that approximately one in six (17%) of the Australian population is affected by hearing loss.³ However, as a result of many years of exposure to harmful noise levels, it is envisaged that Australian farmers have sustained a more significant level of noise injury. For example, in 2002 it was reported that farmers had an average hearing-age profile 10–15 years worse compared to the general Australian population.²

Data from 1417 farmers in Victoria³ showed that over 40% of participants (49.9% of men and 29.1% women) self-reported hearing difficulties in at least one ear, and 31% participants reported trouble hearing in both ears.

Correspondence: Dr Warwick Williams, National Acoustic Laboratories, 126 Greville Street, Chatswood, New South Wales, 2067, Australia. Email: warwick.williams@nal.gov.au

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What is already known on this subject:

- Many farming activities are noisy and represent a hearing health hazard to those working and living on farms in Australia.
- Regular exposure to noise results in a progressive hearing loss.
- For those affected hearing loss can produce frustrations in daily life including personal, family, social and economic difficulties.

In total 36.7% of farmers aged less than 60 years suffer some form of hearing loss, while 53.7% age 60 or above suffer from hearing difficulties. These figures are likely to be under reported⁴ due to the social stigma associated with ‘deafness’ and often unrecognised due to the insidious nature of the hearing loss. As a result, prevalence rates can be distorted in terms of the incidence and level of hearing loss. Being able to hear effectively or able to adjust behaviours to compensate for hearing loss is important in avoiding potential accidents. This is particularly important on farms where the workplace is the home, where extended families live, where children play, where friends visit, all in close proximity to operating machinery and, sometimes unpredictable, livestock. In the United States, hearing loss has been causally associated with an increased incidence of farm-related accidents.⁵

Hearing loss impacts across life, work and family domains, and has significant adverse psycho-social effects on those involved. Notably, people with hearing loss report increased rates of affective mood disorders and poorer social relations.⁶ Hearing loss is described as an underestimated health problem, with adult hearing loss associated with increased risk for a variety of health conditions including diabetes, hypertension, heart attack and psychiatric disorders.⁷⁻⁹ Additional research by the Sustainable Farm Families program also found hearing loss associated with high rates of preventable lifestyle risk factors in farm men and women for diseases such as diabetes, cardiovascular disease and cancer.¹⁰

Methods

The field work undertaken for this project consisted of two sections. The first involved the use of dosimetry to gather noise exposure information from individuals working on the farms. This information was used to estimate typical daily noise exposures, then extended to estimate the numbers of Australian farmers exposed to hazardous noise in their workplace. The procedure follows a verified Global Burden of Disease study method^{11,12} by which the numbers of farmers, classified

What this study adds:

- This study of farms (typically family owned) estimates that 51% of farm workers are regularly exposed to daily noise above the accepted Australian Exposure Standard known to produce a long-term hearing loss.
- Women and men have similar noise exposures.
- Using data from the Australian Bureau of Statistics, it is estimated that around 163 000 Australian agricultural workers are affected.
- The use of a simple on farm noise audit in conjunction with appropriate feedback was shown to be effective in raising farmers’ awareness of noise and assist them reducing their noise exposure.

as ‘agricultural workers’,¹³ employed in the Australian workforce¹⁴ is matched to the noise exposure profile determined from the statistical analysis of the current results.

The second section comprised gathering noise measurements considered to be typical of the noisiest regular activities. These activities were summarised in a short report individualised for the particular farm outlining, along with the noise levels, the acceptable exposure time, an explanation of their meaning/implication(s) and brief suggestions about how to reduce noise exposure.

Ethics approval was provided by Deakin University Human Research Ethics Committee, application approval ‘2012-006 Shhh, hearing in a farming environment’.

Analysis of the results was carried out using Statsoft Statistica Version 7 (StatSoft, Inc. (Headquarters) 2300 East 14th Street Tulsa, OK 74104 USA).

Subjects

All the individuals who participated in this project were part of a larger National Health & Medical Research Council funded project, ‘Shhh-hearing in a farming environment’ (APP1033151) coordinated by the National Centre for Farmer Health, Deakin University, at the Hamilton, Victoria campus. The subject cohort was a convenience sample drawn from the Sustainable Farm Families (SFF) Program, an initiative of the Western District Health Service, Hamilton, Victoria, targeting the long-term health, well-being and safety of those working on farms. Participants were volunteers and had previously self-reported hearing difficulty during the SFF program.

The location of the farms, and the participants, were from Victoria and southern Queensland, Australia, and included farms involved in dairy, beef, wool, prime lamb, pork and cropping.

Noise measurements and assessment

Field measurements were carried out by trained health professionals using a CEL-244 digital integrating sound level meter (SLM), for the direct noise measurement for sampled farm activities, while CEL-350/K4 dBadge personal sound exposure meters (PSEM) were used to assess personal noise exposure. Both sets of measurements were conducted in accordance with the measurement and calibration procedures required by the combined Australian/New Zealand Standard AS/NZS 1269: 2005.¹⁵

Results

Noise levels

As part of the farm survey, typical noise levels from numerous farm activities were measured. The noise measurements were carried out for purposes of the noise report (see below) and to demonstrate the relative loudness (L_{Aeq}) of tasks and machinery to participating individuals. A summary of these measures is presented in Table 1. These results are similar to previous research.^{16,17}

These measured noise levels were not used in the estimation of daily noise exposure as this would have required estimation of typical exposure times for each individual activity. Daily exposure information came solely from the PSEM records.

Noise exposures

A summary of the personal noise exposure parameters is presented in Table 2 as mean values and standard deviations (SD). A simple *t*-test statistical analysis showed no difference in the exposures (Pa^2h) or other results between women and men. Specifically for: mean exposure ($L_{Aeq,8h}$, dB) $P = 0.39$; mean peak level (L_{Cpeak}) $P = 0.44$; mean exposure (Pa^2h) $P = 0.92$; and mean exposure time (i.e. length of working day, hours) $P = 0.94$. Hence for discussion purposes, the results can be regarded as a single cohort of women and men.

Discussion

Noise exposed individuals

Using figures available for 2010, there were 318 200 employed persons¹⁴ in the 'Agriculture' subdivision,

Australian New Zealand Standard Industrial Classification¹³ code 'A01'. Assuming that noise exposure is distributed in a statistically normal manner across this subdivision, it can be estimated that the fraction of this population exposed to noise above the exposure Standard is 0.512 (51%) representing 163 000 individuals. This estimation does not take into account the effects of any exposure reduction measures, such as wearing hearing protectors, taken while performing these activities. This exposure is estimated as required by the Australian Standard¹⁵ for occupational noise management and work health and safety regulations (e.g. Work Health and Safety Regulation¹⁸). Analysis shows that a further 57 000 individuals (18%) are exposed to levels above $3.2 \text{ Pa}^2\text{h}$ (i.e. 90 dB $L_{Aeq,8h}$).

Noise reports

The report for each farm was produced to a standard format designed for ease of interpretation by readers who might not be familiar with such reports. For simplicity, the format of the report was a single, double-sided A4 sheet which when folded appropriately produced an A5, four-page booklet.

Following the on-farm noise audit and receipt of the noise booklet written feedback was sought through a short questionnaire (seven questions) concerning the effectiveness/relevance of the report booklet. Responses were received from 85 (81%) of the 105 participants. The questions and results are summarised in Table 3.

The majority of participants indicated they found the presentation of the information was useful and aided their understanding of farm noise, hearing health, noise sources and future preventative action.

Noise exposure

The finding that female and male exposures are similar should not come as a surprise if we consider that in the farming environment under study consisted of small, family-owned farms where all participants, female and male, regularly undertake similar tasks. Overall, the average exposure among the farmers was greater than the current recommended Australian Exposure Standard¹⁹ of 85 dB ($L_{Aeq,8h}$) or $1.01 \text{ Pa}^2\text{h}$ (Pascal squared hours). This general result means that those involved in farming activities must reduce their overall noise exposure to maintain their hearing health.

Noise exposure on farms is traditionally seen as a problem with a strong male bias simply because most of the active farmers were assumed to be male.^{4,16} The results presented here demonstrate that this is no longer the case. The farms visited were family based where the

TABLE 1: Noise levels (L_{Aeq} dB) of typical, measured farm activities and equipment

Activity area	Specific activity	Noise level (range) L_{Aeq} (dB)
Driving	Tractor	72–99
	Utility vehicles and trucks	69–82
	Header	77
	Bobcat	83
	Ride-on mower	98–101
	Motor bike	89–93
	Boat	96
	Quad bike	79–90
	Motor bike	76
	Spraying from tractor	81
Tools and machinery	Drop saw	102
	Post hole digger	88
	Brush cutter	87–96
	Cordless drill	79
	Grinder	90–102
	Chain saw	99–119
	Log splitter	82–102
	‘Flymo’ lawn mower	93
	Push mower	87
	Leaf blower	84–87
	Whipper-snipper	90
	Post driver	101–110
	Rattle gun	74
	Wool press	82–87
	Auger	85–98
	Power ladder	87
	Generator	92
Dairy vacuum pump	73	
Air compressor	82–90	
Fire pump	92	
Farm activities	Metal work	97
	General carpentry work	70–78
	Chopping wood	75
	Mustering sheep and cattle	70–91
	Feeding sheep and cattle	75–90
	Foot wash sheep	79
Domestic activities	Shearing shed	75–80
	Kitchen, vacuuming	65–80
	Paperwork, computing	65–70
	Gardening	65–86

farming workload was shared between family members, male or female, a change from the old model where men worked the farm while the female role was mostly around home. For the future, this means that noise injury prevention campaigns must address all involved on the farm.

While most noise exposure surveys of farms are characteristically task based,¹⁷ the analysis of the dosimeter

results while typical of most workplaces did indicate the more unusual aspects of data gathering from farming activities not found at conventional workplaces. For example, while normal day-time activities included driving tractors, operating farm plant and machinery, welding, grinding, general repairs, motor bike/quad bike riding and livestock handling, unexpected but significant events such as, feral animal control and/or shooting

TABLE 2: Summary of farmer noise exposure assessment results

Group	Subjects (n) (%)	Exposure (L _{Aeq,8h}) (dB) [Range]	L _{Cpeak} (dB) [Range]†	Exposure (Pa ² h) [Range]	Exposure time (h) [Range]
All (m + f)	51 (100%)	85.3 [70.9–96.7]	134.6 [122.0–143.5]	1.09 (SD = 2.4) [0.04–14.9]	15.2 (SD = 8.5) [1.5–28.5]
Females (f)	14 (27%)	85.2 [70.9–94.1]	135.7 [122.0–143.5]	1.14 (SD = 2.3) [0.04–8.3]	15.4 (SD = 8.9) [2.0–25.7]
Males (m)	37 (73%)	85.5 [71.1–96.7]	134.2 [122.4–143.5]	1.07 (SD = 2.5) [65.9–93.6]	15.2 (SD = 8.5) [1.5–28.5]

†An L_{Cpeak} value of 143.5 dB is the upper limit of measurement for this parameter on the CEL-244 SLM.

TABLE 3: A summary of the results of the usefulness of the on-farm noise exposure reports

Measure	Agree % (n)	Disagree % (n)	Undecided % (n)
The farm visit was successful in updating my knowledge about farming tasks that affect my hearing	99 (84)	0 (0)	1 (1)
The farm noise control booklet updated my awareness of influencing my health status	99 (84)	0 (0)	1 (1)
The farm noise control booklet provided information about noise-induced hearing loss	98 (83)	0 (0)	2 (2)
I found the language and concepts in the noise control booklet easy to grasp	99 (84)	0 (0)	1 (1)
The results of the farm noise audit have motivated me to use hearing protection	95 (81)	4 (3)‡	1 (1)
I would recommend a farm noise audit to other farmers	99 (84)	0 (0)	1 (1)
I felt comfortable wearing the dosimeter (n = 23‡)	100 (23)	0 (0)	0 (0)

‡The 4% that disagreed to ‘the results of the farm noise audit have motivated me to use hearing protection’ all commented that this response was given due to the fact that they already wore hearing protection; ‡for logistical reasons only 23 of the dosimeter-wearing participants were asked this question.

in the evening, provide unanticipated, important noise exposure sources that might be missed when day-time work hours are only considered.

Hearing protector use

While the use of hearing protectors is an effective method of noise exposure reduction, they are only an effective solution if the devices are worn correctly, fit for purpose and worn for the whole of the exposure duration. Take the recorded maximum exposure of 14.9 Pa²h as an example. If this individual was able to find and wear hearing protectors that reduced all of the external noise (equivalent to an infinite attenuation) but wore these for only half of the total exposure time, their protected exposure would be reduced to 7.8 Pa²h, a significant reduction but still well above the exposure limit of 1.01 Pa²h.²⁰

Part of the *Sbbb* project involved a session on hearing protectors, their use and efficacy including an explanation of the types of hearing protectors avail-

able, the classification system for hearing protectors²¹ and their correct fitting.²² While most participants were familiar with hearing protectors as such (plugs and muffs) the classification system¹⁵ was unfamiliar and viewed as important, new information in this context.

On-farm noise reports

The on-farm noise reports proved to be much better accepted than anticipated. Some typical responses to the open-ended question ‘What do you like about the noise control booklet?’ were:

- I like the personal touch. Something I can show my staff and say ‘this is why we wear ear protection’.
- Awareness of noise causing hearing problems.
- Concise and a good reference. Well set out and easy to read.
- It is very interesting having actual noise values for my machinery and not just generic figures for

average machines. It reinforced my need for hearing protection on these machines.

- It alerted me to the high noise of much machinery which I had taken for granted – without hearing protection.
- Makes you stop and think about many farming tasks.
- The booklet has made me aware of how far in excess of recommended safe levels the implements that I farm with have the potential to damage my hearing (a lot of damage already done) (ear muffs always close by).

These results indicate that the reports were useful and understood by recipients. Prior research indicates that most of the information received by farmers concerning the harmful effects of noise exposure is presented in a general sense from health care and other professionals.²³ This intervention ‘personalised’ the effort using researchers who were familiar with farming practices and concentrating on the tasks and procedures used by the farmers concerned, highlighting their exposure and involving them in potential solutions. The personalisation makes people part of the solution.

Limitations

While there are certain limitations on this study particularly in relation to the number of individuals involved, the results can certainly be considered indicative of typical noise exposures arising from routine farm work activities. The wide range of sample times for which noise dosimeters were able to be worn also indicates that there are difficulties in accessing farm workers for the distribution and collection of dosimeters.

Data collection was also limited and constrained to an extent by the incidence of floods, fires and drought that placed certain restrictions on the researchers’ ability to access farmers during these stressful times. Hence, a full cycle of the typical seasonal and yearly activity might not have been adequately sampled.

Conclusion

The results of this work shows that more than 51% of the farm workers surveyed are exposed to noise above the recommended Australian Exposure Standard. Exposures ranged from 0.04 Pa²h (71 dB) to 14.9 Pa²h (97 dB), the equivalent of 15 times the recommended exposure standard. Extension of these results to the agricultural workforce reveals an exposed population of 163 000.

The simple on-farm noise audits and report booklets provided to farmers on noise level management, and their significant noise sources proved to be an effective awareness raising and noise exposure management tool.

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References

- 1 WHO. *Environmental Health Criteria 12 NOISE*. Geneva: World Health Organisation, 1980.
- 2 Williams W, Forby-Atkinson L, Purdy S, Gartshore G. Hearing loss and the farming community. *Journal of Occupational Health & Safety – Australia and New Zealand* 2002; **18**: 181–186.
- 3 Access Economics. The economic impact and cost of hearing loss in Australia, a report by Access Economics P/L 2002, Canberra.
- 4 Brumby S, Willder S, Martin J. The sustainable farm families project: changing attitudes to health. *Rural and Remote Health* 2009. [Cited 22 October 2014]. Available from www.rrh.org.au/articles/showarticlenew.asp?ArticleID=1012
- 5 Hogan AE, Noble WG, Munnerley G. Coping with occupational hearing loss: The University of Montreal Acoustics Group Rehabilitation Programme. *Journal of Occupational Health & Safety – Australia and New Zealand* 1994; **10**: 107–118.
- 6 Choi SW, Peek-Asa C, Sprince NL *et al.* Hearing loss as a risk factor for agricultural injuries. *American Journal of Industrial Medicine* 2005; **48**: 293–301. doi: 10.1002/ajim.20214
- 7 Hogan A, O’Loughlin K, Kendig H. The impact of hearing loss on personal health – a threshold effect model. *Journal of Aging and Health* 2009; **21**: 1098–1111.
- 8 Wilson D, Walsh PG, Sanchez L, Read P. *Hearing Impairment in an Australian Population*. Adelaide, SA: Department of Human Services Centre for Population Studies in Epidemiology, 1998.
- 9 Hogan A, Doyle J, Osborn R, Fitzmaurice K, Kendig H. The communication and health needs of older people with hearing loss: are hearing aids enough? *Australian Journal of Audiology* 2001; **23**: 10–17.
- 10 Mitchell P The prevalence, risk factors and impacts of hearing impairment in an older Australian community: the Blue Mountains Hearing Study, The 4th Libby Harrick’s Memorial Oration 2002, Deafness Forum, Canberra, Australia.
- 11 Lim SS, Vos T, Flaxman AD, *et al.* A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet* 2012; **380**: 2224–2260.
- 12 Williams W. The epidemiology of noise exposure in the Australian workforce. *Noise and Health* 2013; **15**: 326–331. September–October, 2013.

- 13 ANZSIC. *Australian New Zealand Standard Industry Classification*. Canberra: Australian Bureau of Statistics, 2006. ref 1292.0.
- 14 ABS. *Australian Labour Market Statistics – 6105.0 April 2010*. Canberra: Australian Bureau of Statistics, 2010.
- 15 Standards Australia. *Australian/New Zealand Standard AS/NZS 1269: 2005 Occupational Noise Management*. Sydney: Standards Australia, 2005.
- 16 Depczynski J, Franklin RC, Challinor K, Williams W, Fragar L. Factors affecting farm noise during common agricultural activities. *Journal of Agricultural Safety and Health* 2006; **12**: 117–125.
- 17 Depczynski J, Fragar L, Challinor K. Changes in the hearing status and noise injury prevention practices of Australian farmers from 1994–2008, A research report on the NSW Rural Noise Prevention Program, A co-joint activity of The Australian Centre for Agricultural Health and Safety and the Hunter New England Area Health Service, Australian Centre for Agricultural Health and Safety, University of Sydney, 2010; PO Box 256 Moree, NSW, 2400, Australia.
- 18 WorkCover NSW. *Work Health and Safety Regulation*. NSW: WorkCover, 2011.
- 19 National Occupational Health & Safety Commission. *Occupational Noise, National Standard (NOHSC: 1007(2000)) and National Code of Practice (NOHSC: 2009 (2000))*, 2nd edn. Canberra, ACT: National Occupational Health and Safety Commission, July 2000.
- 20 Williams W. The estimation of noise exposure when using hearing protectors. *Journal of Health, Safety and Environment* 2012; **28**: 101–105.
- 21 Williams W. The classification system for hearing protectors. *Journal of Occupational Health and Safety – Australia and New Zealand* 1999; **15**: 471–474.
- 22 Standards Australia. *Australian/New Zealand Standard AS/NZS 1269.3: 2005 Occupational Noise Management – Part 3: Hearing Protector Program*. Sydney: Standards Australia, 2005.
- 23 Lower T, Fragar L, Depczynski J, Fuller J, Challinor K, Williams W. Social network analysis for farmers' hearing services in a rural community. *Australian Journal of Primary Health* 2010; **16**: 47–51.