

*Original Research Study*

## **The Hearing Status and Exposure to Noise of Early Childhood Centre Staff**

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**Key words:** Noise exposure, noise induced hearing loss, hearing threshold levels

### **Abstract**

*A study investigated the sound exposure that children and teachers receive in childcare centres. During this study, requests for concurrent work to evaluate the hearing acuity of the teachers resulted in a small extra study. Personal sound exposures were measured on 73 teachers in early childhood education centres and compared to the prescribed levels for workers in the health and safety in employment legislation. Twenty eight teachers in part-time (sessional) centres and 45 teachers in all day centres were tested over one working day. One staff member of a sessional centre and five of those in all day centres received noise exposures well in excess of the 100% maximum daily sound exposure permitted in the workplace. Standard hearing tests were conducted on a small group of 20 teachers including young adults through to those nearing retirement. There was a noticeable increase in noise-induced hearing loss as age increased with significant loss evident in the older participants. The paper argues that if this study has transferability across this teaching population, then potential hearing loss from noise exposure is of concern for early childhood teachers.*

### **Introduction**

Noise exposure levels and resultant health issues of teachers have become of increasing concern in early childhood centres. This was demonstrated during the consultation process conducted by the Ministry of Education in the revision of early childhood centres legislation where a number of respondents identified noise levels as an issue which needed to be addressed (Pairman, personal communication, 30 October 2004). Occupational hearing loss is always of concern in noisy work environments. New Zealand has adopted widely used international criteria for noise exposure in the workplace. Regulation 11 of the Health and Safety in Employment Regulations 1995 requires an employer to take all practicable steps to ensure no worker is exposed to sound pressure levels greater than:

- An A-frequency weighted time-average level over an 8-hour working day of 85 dB ( $L_{Aeq} 8h = 85$  dB) or equivalent. This can be expressed as 100% dose
- A peak level ( $L_{peak}$ ) of not more than 140 dB

A peak level can be regarded as a shock wave of less than one second in duration which is generated by a sudden impact such as a door being slammed. Any peak level over 140 dB is

deemed to be harmful. The shock wave produced is a pressure wave and if over 110 dB, the impact can sometimes be felt on the chest wall.

A code of practice, promulgated under the *Health and Safety in Employment Act 1992* for the management of noise in workplace (Occupational Safety and Health, 2002) gives a statement of preferred work practices and guidance in meeting the requirements of the legislation. While the legislation applies to all workplaces, it was never envisaged that the provisions relating to noise in the legislation itself or the code of practice would apply to schools and early education environments. By strictly applying the provisions in the legislation and accompanying code of practice, one would see the children being isolated from their teachers, or the teachers having to wear hearing protectors, which is clearly impractical in early childhood settings (McLaren & Dickinson, 2005). The *Health and Safety in Employment Act 1992* and code of practice (Occupational Safety and Health, 2002) would need major amendments to cover noise exposure for teachers in early childhood and school environments.

In assessing a noise hazard, Occupational Safety and Health (1994) stated that apart from personal and environmental monitoring of noise levels, a simple rule-of-thumb method can be used as a general rule (in smaller workplaces). It is generally accepted that a noise hazard exists if:

1. There is difficulty in communication while in the noise.
2. A more formal statement of this is that if the voice has to be raised to carry on a conversation with a person about one metre away, then the A-frequency weighted noise level is higher than 85 dB.
3. There is ringing in the ears (tinnitus) after exposure to the noise; or Hearing seems muffled after leaving a noisy area.

The second and third points above relate to the response of the ear to excessive noise exposure. Tinnitus is defined as is a subjective sensation of noise (ringing or clicking) in the ears or head in the absence of an external noise source or auditory stimuli (Marieb & Hoehn, 2007). In this circumstance, it is a clear warning sign of impending hearing damage. A person does not have to experience tinnitus to suffer noise-induced hearing loss (Occupational Safety and Health, 1994).

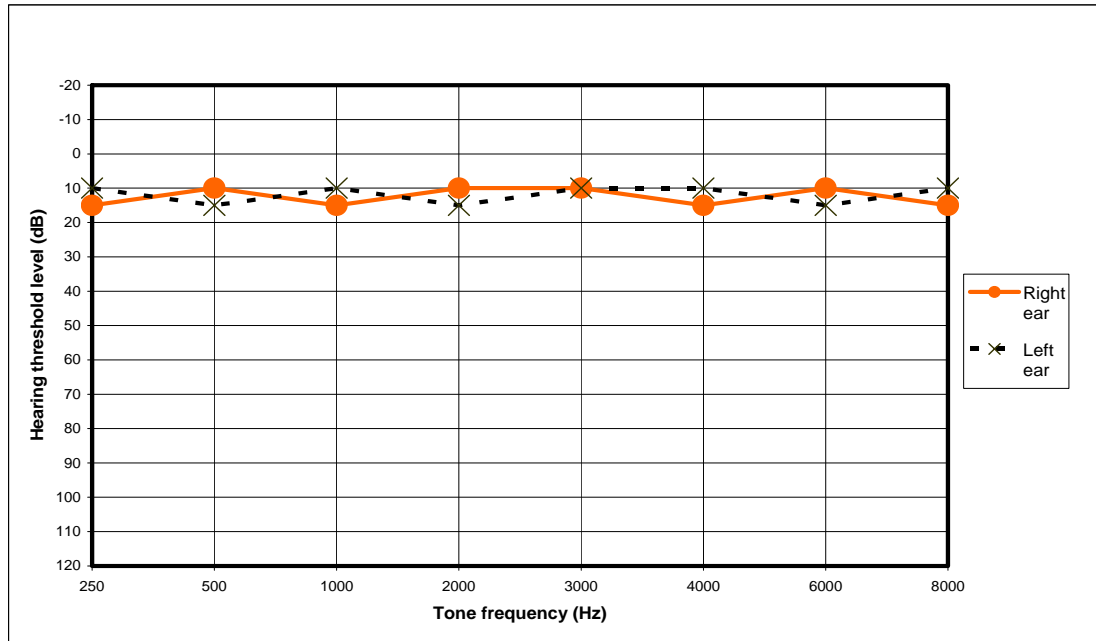
### ***Hearing Impairment and Deafness***

Hearing impairment or loss usually involves a malfunction of the ear and auditory nerves and can be defined as a reduction of hearing ability of variable cause, degree, duration and effect (Public Health Commission, 1995). One of the most common forms of hearing loss is that caused by prolonged exposure to excessive noise is referred to as noise-induced hearing loss (or noise-induced permanent threshold shift) which is usually of gradual onset and irreversible. Noise-induced hearing loss begins as a result of the degeneration of the hair cells in the inner ear (organ of Corti) in the audible frequency region of 4,000-6,000 Hz (Occupational Safety and Health, 1994; Melnick, 1998).

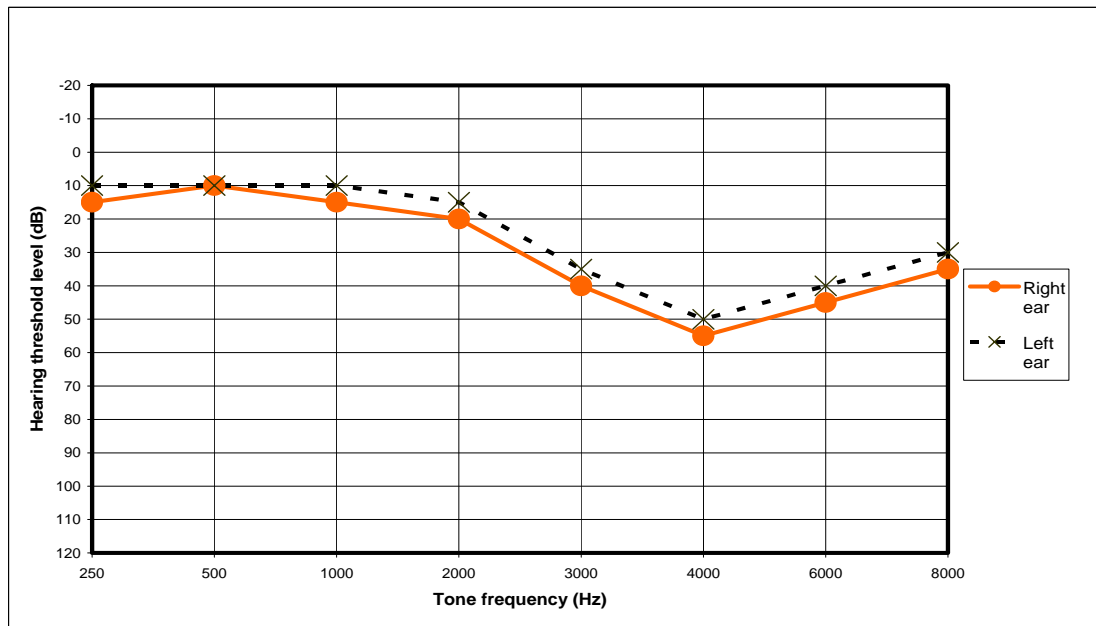
Representative audiograms of hearing are given below. Figure 1a represents normal healthy hearing in both ears where the hearing threshold level does not fall below 20 dB across the audible frequencies. Figure 1b demonstrates an audiogram of a person suffering a typical noise-induced hearing loss in both ears. There is a characteristic notch or V shape of the audiogram in the frequency regions of 4,000-6,000 Hz. This is the most common diagnostic tool for many kinds of hearing loss.

**Figure 1.** Examples of representative audiograms

(a) An example of an audiogram within normal healthy range of hearing



(b): An audiogram of a person with noise-induced hearing loss



Source: Adapted from Occupational Safety and Health (1994)

A temporary threshold shift can occur after exposure to a critical level of noise. It is defined as the temporary increase in the threshold detection of sound which will return to normal in a short time (Small & Gales, 1998). A person with this condition notices a dullness or muffled effect of sound as well as experiencing a difficulty in hearing or speech discrimination in background noise (Occupational Safety and Health, 1994).

A temporary threshold shift may also be an early warning sign of impending damage and can be determined by pure tone audiometry. An audiogram is firstly taken after a quiet rest period, which is usually at the start of the working day or shift (pre-exposure). Following exposure to noise, an audiogram is taken again (post-exposure) and compared to the 'pre-exposure' audiogram. Any significant rise of the hearing detection levels can be regarded as a temporary threshold shift. Hearing will return to the normal threshold level from a temporary threshold shift provided that sufficient time is allowed (can exceed 48 hours) for recovery, which depends on the intensity and duration of the sound. Where further exposure to noise occurs before full recovery can occur, the threshold shift may become a permanent threshold shift, which is more commonly referred to as noise-induced hearing loss (Occupational Safety and Health, 1994; Melnick, 1998). For this reason an assessment of noise exposure and resultant temporary threshold shift is an indication of potential hearing damage.

### **Research Approach**

This study and analysis was planned around the following three research questions:

1. What are the typical sound exposure levels experienced by early childhood centre staff?
2. What is the hearing status of New Zealand early childhood teaching staff?
3. Do early childhood teaching staff experience temporary threshold shifts in their hearing due to levels of noise exposure during the working day?

### ***Personal Sound Exposures of Staff***

In addressing the first research question, three daily sound exposure categories were formulated by the researchers. Those of less than 50% of the maximum permitted dose do not present any concern because they are well below the permitted maximum of 100%. The second category (50-100% dose) still complies with the legislation but is approaching the maximum permitted level. Finally, the third category (greater than 100%) is of major concern because it transgresses the maximum legal requirement.

Reid et. al., (2005) state that this limit of 100% dose is based on a trade-off between practicality and protection. It is derived from population statistics and not individual data. There are a wide variety of factors such as variation in noise exposure conditions, working conditions, individual susceptibility to noise-induced hearing loss etc. They conclude that there is no guarantee that those exposed to daily sound exposures of less than 100% dose for their working life will not suffer hearing loss.

Individual teachers were monitored over a full working day for their daily sound exposure using new lightweight doseBadges and personal sound exposure meters (dosimeters) for teaching and contact staff. Sound exposures of 45 staff members in total for the study-in-progress has previously been reported (McLaren & Dickinson, 2005). On completion of the study, a total of 73 staff members (45 participants from 20 all day centres and 28

participants from 12 sessional centres had been evaluated. The personal sound exposure equipment recorded the following relevant data:

- A-frequency weighted time-average level ( $L_{Aeq\ t}$  dB) for the entire work period “t”
- Percentage dose is the amount of sound exposure relative to the exposure limit for the working day expressed as a percentage of the limit. A noise dose of 100% is equivalent to an A frequency weighted time -average level of 85 dB over an 8 hour day or equivalent energy to this amount.
- Peak level ( $L_{peak}$  dB)
- Time history for each event.

### *Audiometric Testing*

In assessing the hearing status of staff (research question two), audiometric testing was carried out before work began (pre-exposure to noise). This part of the study originated from a number of requests from early childhood centre staff expressing concern about their hearing status and requesting the research team for assistance. The manager of one large centre specifically requested hearing test for the staff and sought some indication if noise exposure at work was a risk factor to the aural health of the staff.

The participants self-selected in response to an offer in writing made by the researchers through the centre managers. Despite the number of responses received, the work culture of long hours and rosters made the conducting of testing very difficult. Tests were scheduled between 5am to 7am where possible, to allow enough time for all participants to be tested before work and again after each worker had finished for the day. This meant that only the two large centres that were located close to Massey University could be considered.

The 20 participants, whose hearing was tested, ranged from age 19 – 65 years old. Audiograms were taken with the current standardised procedure for presentation of tones prior to the start of the working day, to establish the normal hearing threshold of each participant (research question two). To investigate the effects of noise in the workplace on the temporary hearing threshold levels (research question three), a personal sound exposure meter or doseBadge was fitted to each staff member following the first audiogram to record noise exposure during that working day. At the end of the working day, the personal sound exposure device was removed and a second audiogram using the same standardized procedure was taken to determine any temporary threshold shift in the person’s hearing and to relate this to the personal sound exposure level. A screening audiometer (known as a GSI17) was used for all audiometric testing which was carried out either at Massey University or at the particular early childhood centre.

Participation was completely voluntary but all the staff that were present at the testing times wished to participate. Full Human Ethics Committee approval was obtained and the conditions of approval and the requirements of the Health and Safety in Employment Act 1992 for testing of workers were strictly applied. All participants gave signed written consent. Individual results with explanations were given discreetly in sealed packages addressed to each participant to meet the strict legal and ethics committee requirements. Participants were also given advice about health providers who could undertake further tests and consultation.

Background noise presented major issues in conducting the audiometric testing as no testing booth was available. Staff from the first centre elected to have their hearing tested before the start of work at Massey University. Even though the Massey University space was normally very quiet, the noise of heavy rain on the roof and water running down gutters became a major source of distraction. There were major difficulties in detecting the tones in the lower frequencies probably due to masking effects. Staff from the remaining centre wished to have their evaluations done at their premises. For those on the later rosters who arrived after children were present, a number of the tests had to be done while children were present with the noise presenting a major source of distraction. In addition, time was constrained with staff having limited time available before commencing duties. The noisy testing conditions and time constraints compromised reliability. However the results were useful as participants who had not previously consulted an audiologist, were able to gain an approximate status of their hearing.

## Results

### *Daily Sound Exposures*

The individual daily sound exposures (or daily noise doses) are presented in Table 1. These were recorded over one working day for each participant.

**Table 1:** Daily sound exposures of 73 early childhood centre teachers

Daily sound exposure (% dose)	All day centres- staff numbers (45 in total) (% of total)	Part-time (sessional) centres -staff numbers 28 in total (% of total)	Combined staff numbers 73 in total (% of total)
Less than 50%	31 (69%)	23 (82%)	54 (74%)
50-100% dose	9 (20%)	4 (14%)	13(18%)
Greater than 100%.	5 (11.0%)	1 (4%)	6 (8%)

### *Peak Levels*

The highest level permitted under the Health and Safety in Employment Regulations 1995 is 140 dB. The following peak level exceedances were recorded over one working day:

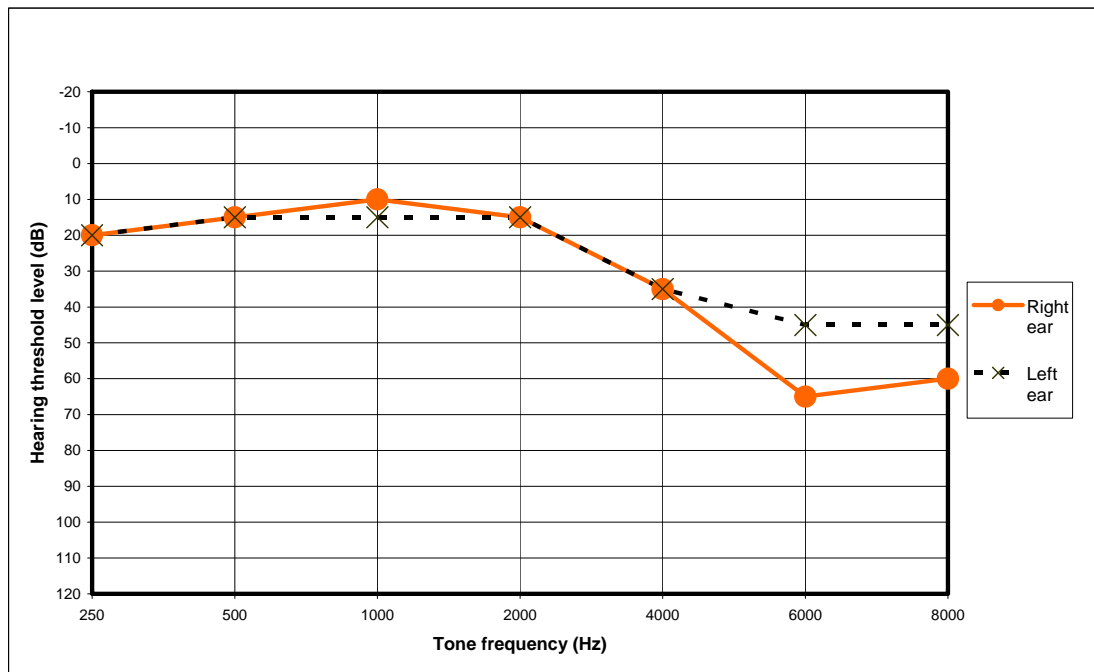
- In all day centres 19 participants of 45 in total (42%) recorded at least one peak level exceedance over 140 dB.
- In part time sessional centres, 11 participants of 28 in total (39%) recorded at least one peak level exceedance over 140 dB.
- In all day centres and part-time (sessional) centres combined, 30 participants of 73 in total (41%) recorded at least one peak level exceedance over 140 dB.

Due to limitations of the equipment, further information on possible numbers of exceedances, when they occurred or the peak levels obtained could not be determined.

*Hearing Status of Participants*

Half of the participants tested showed the likelihood of developing noise-induced hearing loss, which is characterised by an increase in the threshold values in the 4000- 6000 Hz frequency range (or the ‘characteristic notch’ at these frequencies as shown earlier in Figure 1b). In the younger teaching staff (under 25 years of age), noise-induced-hearing-loss was not evident from their audiograms. The audiograms of several participants aged in the 30-35 age group presented a small notch or V shape in the 4,000-6000 Hz region, which is characteristic of noise-induced hearing loss. This trend continued with a noticeable increase in the level of noise-induced hearing loss as age increased. Two participants in the 40-45 age group both presented with significant hearing loss and a participant in the over 50 age group experienced the highest level of hearing loss. The audiogram is given in Figure 2. This participant would be classified as presenting with moderately severe hearing loss.

**Figure 2:** Audiogram of a staff member in the over 50 age group.



The characteristics of many audiograms pointed clearly to noise-induced hearing loss. While the majority of participants had worked in early childhood centres for the substantive part of their working lives we were not able to estimate the contributions from work versus noisy leisure activities. This is a limitation of this study and an aspect which needs to be addressed in future research which is urgently needed to determine the extent of hearing loss, which exists in teachers of the early education sector and the amount that can be reasonably attributed to occupational exposure.

### *Temporary Threshold Shifts in Hearing of Participants*

Only one participant presented with a noticeable shift in hearing threshold. She reported comforting distressed children close to her ear and had a noticeable increase in the hearing threshold of the left ear, which was closest to the children when she held them. These incidents occurred later in the day. The overall dose was 70% for the full working day (below the permitted maximum level of 100%) but examination of the noise exposure received showed higher noise exposure levels received in the latter part of the working day. This participant, a young female worker of 20 years of age presented good hearing in pre-exposure audiometric tests for the right and left ears but the threshold for the left ear rose significantly in the main audible frequencies of 4000 Hz (20 dB increase), 6000Hz (15 dB increase) and 8,000 Hz (10 dB increase) when her hearing was retested at the end of the working day. Likewise there was a smaller but similar rise in the hearing threshold for the right ear in the same frequencies. The testing of other subjects for changes in hearing threshold levels as a result of workplace exposure to noise showed slight but not significant differences.

### **Discussion**

The first research question investigated the typical sound exposures for early childhood centres staff. Six participants out of a total of 73 participants (8%) recorded levels well in excess of 100% the maximum permitted. A further 13 participants (18%) received daily sound exposures 50-100% and 54 participants received noise exposure levels less than 50%. While there has been an improvement on the levels reported earlier in the progress study by McLaren and Dickinson (2005) with an increased sample size, it is still of concern that a significant number of teachers recorded levels in excess of the maximum permitted daily sound exposure. A similar study by Grebenikov (2006) in Sydney of 25 full-time teaching staff using similar equipment and the same criteria as adopted by the New Zealand legislation, had one staff member with a daily sound exposure in excess of 100% and 3 staff members close to the maximum.

To protect everyone from noise-induced hearing loss, no-one should be exposed to more than about 75 dB averaged over an 8 hour day (about 10% dose) , which the World Health Organization (1999) suggest would not cause occupational hearing loss even with prolonged exposure. However to regulate for this level would be quite unfeasible as costs to industry would be prohibitive due to the level of engineering controls and others mitigation measures needed. To regulate to 50% dose (half that permitted at present), there may still be a small percentage of the workers likely to develop noise-induced hearing loss as a result of exposure to this level over many years due to the variation in individual susceptibilities to noise. The extra cost to industry in the mitigation of noise levels to this level would be considerable. There would be substantive costs to the early childhood sector which could involve a high level of acoustical treatment of centres to mitigate noise levels generated as part of centre activities and sound intrusion from activities outside the centre. In addition specific codes of practice would need to be developed to manage noise levels within current teaching practice strategies.

The second research question investigated the hearing status of a small group of early childhood workers. Despite the problems with the testing environment, three of the workers presented significant hearing loss and a further seven showed clear signs of a developing hearing loss with the characteristic V shape in their audiograms beginning to form. While likely contributions from non-work activities such as noisy leisure activities have not been investigated in this study, it is of concern that half those who participated either presented



with significant levels of hearing loss or presented with a risk of developing significant levels of hearing loss during their working lives.

The third research question sought information about temporary threshold shifts in the hearing of staff due to noise exposure. In one case there was a noticeable increase in hearing threshold values of one staff member after exposure to elevated noise levels. Evaluations of other participants did not reveal any significant temporary threshold shifts. The personal sound exposure rates recorded on staff suggests that this may be an important occupational issue for teachers in early education environments. A comprehensive study is needed to examine the level temporary threshold shifts in hearing of a cross section of early childhood education staff and relate this to the levels of noise exposure. In particular investigation of staff members who receive noise exposures greater than the maximum permitted dose of 100% is justified. Furthermore a dedicated study is now needed to establish the hearing status of teachers and contact staff in the early education sector and to establish the extent of hearing loss due to occupational exposure when compared to other noise contributing activities outside work.

The Department of Labour has largely forgotten this group of workers as being at-risk from excessive noise exposure at work, and this now needs immediate attention. It is of considerable importance to investigate thoroughly the extent of occupational noise exposure with this group of workers, and if a significant risk is established, to implement regular testing programmes as is done with other at-risk workers. It may be necessary, based on establishing the level of risk among these workers, to propose amendments to address occupational noise issues in the legislation and the associated code of practice as applicable to this profession.

## Conclusion

The study investigated the daily sound exposures of 73 early childhood centre staff in all day centres and part time (sessional) centres. Six participants (8%) recorded a daily sound exposure well in excess of 100% dose, the maximum permitted by the Health and Safety in Employment Regulations 1995. A further 13 participants (18%) recorded dose levels of 50-100%. In addition the hearing status of 20 early childhood teachers was investigated. Half of these participants either presented with significant levels of hearing loss or presented with a risk of developing significant levels of hearing loss during their working lives.

Recommendations for research and policy that arise from this study include:

- A wide ranging national study should be undertaken of teachers and assistants across the early education sector to establish levels of excessive noise exposure and hearing loss attributable to the work environment.
- The Department of Labour and the Ministry of Education ensure that regular testing programmes are introduced for occupational hearing loss and noise exposure among early childhood staff.
- Governing bodies introduce appropriate policies on mitigating noise exposure for the staff as well as children, and provide opportunities for all staff to undertake regular hearing evaluations.

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Stuart McLaren (Senior Lecturer in Health Science) and Philip Dickinson (Professor of Acoustics) are specialists in teaching and research in environmental, occupational and educational noise issues in Massey University's Institute of Food Nutrition and Human Health on the Wellington campus. Stuart completed his PhD in 2008 and has a special interest in the effects of noise on children (especially those with special needs) and staff in early education. Professor Dickinson has a special interest in the issues and problems caused by recreational noise.