Assessment of life course noise exposure

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INTRODUCTION

Any sound will cause hearing loss as long as it is loud enough and of sufficient duration. NIHL in the workplace, however, mainly arises from continual exposure to loud sound (noise) above a level of around 80-85 dBA and is recognized as an occupational disorder in many work settings (Dobie 2001). Acute exposure to very loud sound can also lead to rapid damage to the ear and loss of hearing. Loud sound is also a hazard in non-work related environments but the distinction between the two contexts is increasingly recognized as artificial and unhelpful (Smith et al. 2006). The hearing loss occurs because of damage to the hearing organ (cochlea) of the inner ear; mainly the auditory sensory hair cells and their associated nerves (Thorne & Gavin 1987; Wang et al. 2002).

The severity of the hearing loss and rate at which it develops is defined primarily by the level and duration of the exposure. The New Zealand national standard for occupational exposure to noise is an eight-hour equivalent continuous A-weighted sound pressure level of 85 dB L_{Aeq},8h, while the maximum peak level permitted is 140 dB LC,peak. This is set in law by Health and Safety in Employment Regulations (1995). With repeated exposure at this level over a working week, only 5 % of the exposed population should have a hearing loss greater than 10 dB over a working lifetime (Standards Australia/Standards NZ 2005). The risk and severity of hearing loss rises with duration and sound level (Dobie 1995, 2001).

Epidemiological data on NIHL has been collected using various methods including quantitative hearing assessment, self-reports (e.g. European Agency on Safety and Health at Work 2005), questionnaires (e.g. Palmer et al. 2000, 2001) and the number of people receiving compensation for NIHL (Thorne et al. 2006). Estimates of the incidence and prevalence of NIHL in different countries vary considerably. This variation is due to differences between the populations and their noise exposure, and includes: variations in the audiometric criteria for defining degree of hearing loss; differences in hearing conservation programs and use of personal hearing protectors; and in criteria for attributing the proportion of hearing loss due to noise exposure rather than age or other disease. Based on the WHO definition for substantial or significant hearing loss (> ave 41 dB loss for 0.5, 1, 2 and 4 kHz), an estimated one sixth (16 %) of the population with hearing loss worldwide is attributable to occupational noise exposure (WHO 2002). This figure is corroborated by a USA assessment of the contribution of occupational noise exposure to total deafness rates, giving a range from 7 % in developed nations to 21 % in developing regions (Nelson et al. 2005). Part of the difficulty in estimating the rate of NIHL may result from the quality of information about the extent of noise exposure in the nominally noise-exposed populations.

Long-term memory about health factors is generally poor and epidemiological research has sought to use mnemonic tools to improve recall accuracy. We sought to assess life-course noise exposure in a sample of adults using a mnemonic approach:

the Noise-History Calendar. This is based on the Life-History Calendar, which is a well-established instrument used to enhance the quality of retrospective data (Caspi et al. 1996). The technique has not, to our knowledge, been used previously to help identify and quantify historical noise exposure. It takes the form of a series of columns, each representing a year, and extends back in time as long as is necessary to describe the noise exposure of an interviewee. Other events that have occurred in a person's life (e.g. changing jobs, moving house etc.) can be indicated on the Calendar and serve as points of reference to improve the quality of recall.

For noise exposure, both the level of noise and the amount of time exposed is important to understanding an individual's degree of noise exposure. Previous epidemiological research has used the question: "Is the noise at work so loud that you need to shout to converse when you are at arm's length from someone?" This question has been used widely (e.g. McBride 1993) but with little supporting research. The amount of time exposed can be related to the proportion of an eight-hour work shift on the basis of the equal energy hypothesis. Finally, noise exposure should also take into account the use of hearing protection equipment that would have the effect of reducing the noise level at the ear.

It would be useful to have a standard technique for the assessment of lifetime noise exposure. We began work on establishing such a technique.

METHODS

We interviewed 500 people working in a range of economic sectors in New Zealand. Sampling was purposive, to enlist a predominance of workers from the noisy occupations (such as metal manufacturing), but others, currently working in quiet occupations, were also recruited. Participants were mostly (75 %) male, and of NZ European ethnicity (59 %); their mean age was 39 years (SD=12.8; Age range: 17-75 years).

Participants were interviewed at work using the Noise-History Calendar (Figure 1). Their life-course noise histories were explored starting in the current year and progressing backwards through time; to assist with recall, interviewers were instructed to elicit information about different jobs, places of residence, and other life events that the participant could bring to bear on assisting with recall about their working conditions. They were asked to indicate for each occupation and each year what the average percentage of time they were exposed to noise at a level where they had to shout to converse with someone else when they were at arm's length. They were also asked about the proportion of time that it was noisy at this level when they would have worn hearing protection. On the following day, prior to starting work, otoscopy, tympanometry, and pure-tone audiometry (at 1, 2, 3, 4, 6, and 8 kHz) were carried out on each participant. For 443 of the participants, a dosimeter was then attached to them for the full work shift and collected that evening after work.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Job										
Noisy? (Including sudden, loud noises)										
Protection?										

Figure 1: Scaled-down version of a page from the Noise-History Calendar

Several measures of noise exposure were derived:

Years of noise exposure (YNE): This was a simple count of the number of years that each person indicated they had worked in noisy conditions where they had to shout to converse when at arm's length.

Weighted YNE (WYNE): This was the number of years that each person reported being noise exposed multiplied by the proportion of time exposed for each year.

Corrected WYNE (CWYNE): The question asked to standardize reporting levels for noise was whether they had to shout to hold a conversation when at arm's length from other workers. It was not known what level this might have reflected, so a comparison was made between the noise level that each person estimated for his current occupation and the noise level as measured by dosimetry. This yielded a correction factor for each person, depending upon how closely their interpretation of the level of noise exposure at which they would have to shout to hold a conversation was to 85 dBA. This level was used because it represents the legal limit for noise exposure over an eight-hour shift in New Zealand.

RESULTS

Overall, most of those interviewed worked in some noise. The proportion of the group exposed to noise at work had been quite constant over the years (Figure 2).

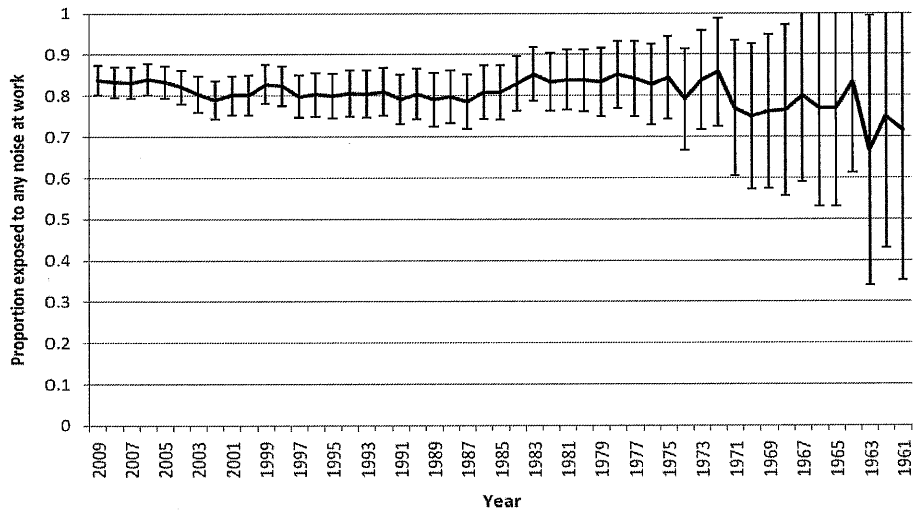

Figure 2: Proportion of those interviewed who were exposed to noise in each calendar year. (Error bars represent 95% CI)

The percentage of time during a work shift that participants estimated they were exposed to noise did not alter across time (Figure 3).

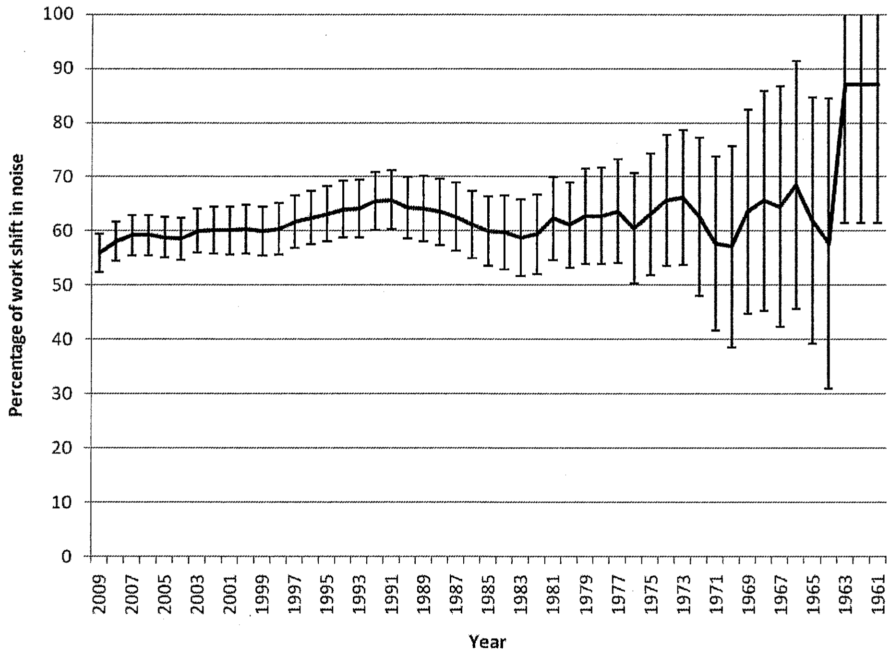

Figure 3: Percentage of time during a work shift that noise was loud enough that it was necessary to shout to converse when at arm's length. Percentages are presented per year, and error bars represent 95% CIs

However, the wearing of hearing protection equipment during noise has increased (Figure 4).

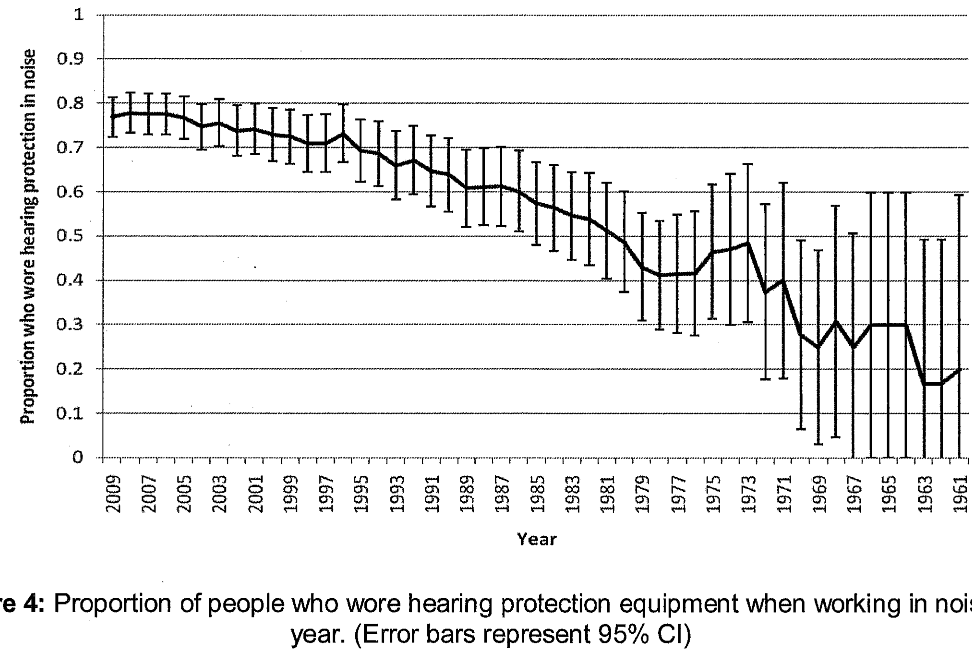

Figure 4: Proportion of people who wore hearing protection equipment when working in noise per year. (Error bars represent 95% CI)

Table 1: Number and percentage who over or underestimated percentage of time during a work shift that they were exposed to noise aranged by noise levels

	75 dB	80 dB	85 dB	90 dB
N employees who **overestimate %NE**	181	249	288	299
%	40.9 %	56.2 %	65.0	67.5
N employees who **underestimate %NE**	257	168	89	41
%	58.0 %	37.9 %	20.1	9.3
N employees with **EQUAL estimate of %NE**	5	26	66	103
%	1.1 %	5.9 %	14.9	23.3

The percentage of noise exposure as measured by minutes of dosimetry above each of the levels (70, 75, 80, 85, and 90 dBA) as a percentage of the total minutes in the shift was compared to each participant's estimate of their noise exposure at a level where they would have to shout to be heard (Table 1). In general, the noise level at which estimates would be evenly split between too high and too low would be at a level between 75 and 80 dBA. This may suggest that our criterion question for noise exposure (shouting to converse at arm's length) was, on average, interpreted by participants as a noise level of about 78 dBA.

Based on this, and given that 85 dB $L_{Aeq,8h}$ is the level regarded by New Zealand law as the criterion for dangerous exposure it was desirable to attempt to correct the discrepancy between the interpretation of our question and the legal criterion. To do this, comparisons were made between dosimetry results and the percentage estimates that participants made for their current jobs. Ratings were then were made for each participant of the noise dose (relative to 85 dB $L_{Aeq,8h}$) associated with their rating of the percentage time exposed. For example, if a participant rated current noise exposure at 100 % and dosimetry showed an actual noise dose of 82 dB $L_{Aeq,8h}$, then this level would be applied to all his estimates of past noise exposure.

Based on this approach, a pattern of noise exposure (relative to the legal criterion) across time was developed (Figure 5). Error bars are wide, but this may suggest that the rate of noise exposure has grown since the 1960s. The result may be an artefact due to older workers being more likely to overestimate current noise levels and thus implying that their noise exposures 40-50 years ago were lower than they really were.

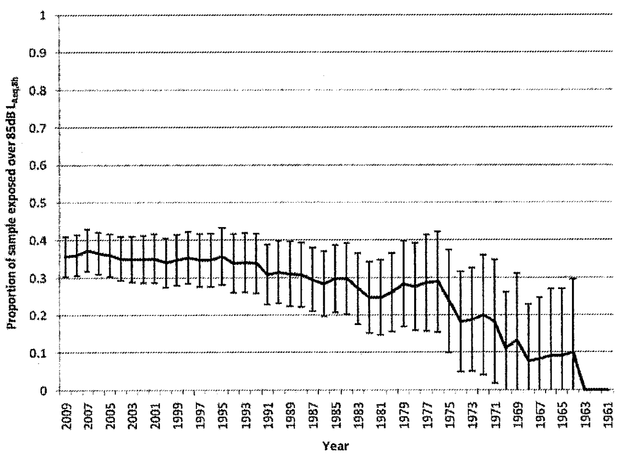

Figure 5: Proportion of the participants who were working in each year whose rated noise exposure percentage translated to a shift exposure >85 dB $L_{Aeq,8h}$. Error bars represent 95% CIs

CONCLUSIONS

The Noise–History Calendar appears to be effective technique for estimating exposure to noise.

It uses a paper calendar as a mnemonic to support recall of noise levels and times of exposure.

Accompanying this are standardized questions to assess the length and level of noise exposure.

Responses to the question, 'Did you have to shout to converse when at arm's length?' tended to reflect actual noise levels between 75 and 80 dBA

Noise exposure rates in New Zealand appear to have been constant or possibly slightly increasing over the last 50 years.

Use of Hearing Protection Equipment when working in noise has increased gradually in the last 50 years and appears to have leveled off at between 70 % and 80 % of workers wearing it over the last two decades.

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