Noise sources, exposures and controls in small enterprises in New Zealand

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Abstract

There is little published data on noise sources related to occupational exposures, particularly in relation to small enterprises (SE's). Most published sound level surveys focus more on exposures and controls and provide little detailed evaluation of noise sources and transmission paths. This paper describes a multiple case study designed to identify, describe and evaluate noise exposures, sources, paths and control strategies used by 30 SE's (employee count less than 20) in "high", "moderate" and "low" risk industry sectors in New Zealand.

Data collection involved workplace observations, noise assessments, semi-structured interviews, self-administered questionnaires, and reference to archival data. In addition to sound level measurements in work areas and personal dosimetry, assessments of each SE's conformance to current noise management standards were undertaken.

Area and personal sound level exposures were found to vary considerably within the "high risk" (agriculture, manufacturing and construction; range 80 - 90 dB $L_{Aeq,8h}$), "moderate risk" (cafes and restaurants; range 60 – 75 dB $L_{Aeq,8h}$) and "low risk" sectors (pre-schools; range 70 - 80 dB $L_{Aeq,8h}$). Generally noise sources and paths could be readily identified in the workplaces. The predominant noise control strategy in 90% of the industry sectors was minimisation, specifically the use of personal hearing protection. In most cases, noise management strategies aimed at the noise source and noise paths could have been investigated further by the management of the small business.

The findings suggest that there needs to be significant changes in expectations with respect to noise management practices and solutions for small enterprises in particular. In addition, national strategies on the prevention of noise-induced hearing loss (NIHL) need to be designed from a small business perspective and where noise management interventions are seen as a benefit to the enterprise rather than a cost.

Keywords: Noise exposure, sources, noise controls, compliance, small business

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1. Introduction

There is little published data on noise sources related to occupational exposures, particularly in relation to small enterprises (SE's). Most published sound level surveys focus more on exposures and controls and provide little detailed evaluation of noise sources and transmission paths. Sound level surveys that have identified noise sources are industry specific and include data from agriculture [1,2]; construction [3,4]; manufacturing [5,6], saw mills [7,8,]; mining [9] and energy [10].

In New Zealand it is difficult to identify exactly how many people are exposed to excessive noise, how many are at risk and how many are affected by noise-induced hearing loss (NIHL) [11]. It has been estimated that approximately one quarter of the New Zealand workforce of 1.47 million workers are affected to some degree by harmful noise at work [2]. Estimates of the prevalence of NIHL (≥ 25 $dBHL_{Ave\ 1,2,3,4\ kHz}$[1]) in the NZ workforce, in 2006, range from 29,242 (based on the WHO calculations) to 42,497 [12]. Extrapolation of the workforce data gives an estimate of the prevalence of NIHL (≥ 25 $dBHL_{Ave\ 1,2,3,4\ kHz}$) in the NZ population, in 2006, range from 62,169 (based on the WHO calculations) to 69,613 [12]. Based on these population data it is estimated that between 1.54 and 1.73% of the New Zealand population had a hearing loss that is solely due to occupational noise exposure. This gives an incidence in the workforce ranging from 1077 to 1537 new cases of NIHL in 2006.

It is also estimated that a large proportion of those exposed workers are employed in small enterprises [13]. The most recent data indicate that 97% of enterprises in agriculture, 92% in manufacturing, 98% in construction,

1 dBHL = decibels Hearing Loss; the dB level relative to the quietest sounds that a young healthy individual ought to be able to hear. In this case the value used was the average over the frequencies of 1,2,3,4 kHz.

92 % in hospitality and 75 % of enterprises in education employ less than 20 employees [14].

The international legislative requirements for control of exposure to noise tend to translate into a requirement to conduct preliminary noise surveys to identify possible hazards followed by detailed sound level surveys of identified noise hazards to assess if they are a significant risk. After this, employers are required to investigate, and if practicable, control the noise at the source and isolate noise sources away from employees. Where it is considered not practicable to eliminate or isolate the hazardous noise source, employers must provide approved hearing protection.

The primary objective of this study was to determine the nature and effectiveness of interventions currently used in small enterprises to control exposure to noise and the incidence of NIHL and identify the barriers to the implementation of noise management strategies and programmes. A secondary objective was to determine whether identified "high-risk" sectors and occupations conform to current industry recommendations and standards (e.g. Codes of Practice) to prevent NIHL.

2. Method

2.1. Study design

A multiple case study design was used to identify, describe and evaluate intervention/ control strategies used by 33 "high risk", "moderate risk" and "low risk" industries in relation to exposure to noise and the incidence and/ or severity of NIHL. Data collection included site visits to identify existing noise control strategies, barriers to adoption of controls, and critical factors that need to be considered when designing and implementing effective noise control interventions.

The industry sectors included in this study were: high risk – agriculture ([2]ANZSIC 0161 diary), manufacturing (ANZSIC 1211 beverages, 1340 knitted products, 1411 sawmilling, 1491 wood products, 2221 steel fabrication) and construction (ANZSIC 3019 residential construction); moderate risk - hospitality (ANZSIC 4511 café and restaurants), and low risk – education (ANZSIC 8010 preschool). These sectors were chosen with reference to the data provided by earlier studies [15] that identified specific industry sectors based on their ACC claims experience for noise induced hearing loss; ACC and Department of Labour target industry sectors for excessive exposure to noise and recommendations from the stakeholder group (comprising industry, enforcement agencies and research administration representatives).

2.2. Data collection and analysis

A combination of quantitative and qualitative techniques was used in the collection of primary and secondary data. The techniques used were workplace observations, noise exposure assessments, semi-structured interviews, self-administered questionnaires, and reference to archival data. Each organisation recruited to participate in the survey was visited and information collected about the organisations included details of work and work areas, existing noise sources and control strategies, and options for reducing noise. Data on exposure to noise were collected including area sound levels and personal sound exposures (noise dosimetry). Observational, interview and archival data were also collected on the extent to which organisations were complying with recommendations (e.g. Approved Code of Practice for the Management of Noise in the Workplace) [16] to prevent NIHL. A 10-point checklist was developed and coded 1 for each item where there was evidence that the requirement had been met, otherwise 0. Scores were summed giving each organisation a score from 0-10.

The sound level surveys used Rion type NA14 sound level meters and Cirrus Research noise doseBadges. A "walk through' survey identified the most noisy areas and activities and these area samples reflected a "worse case" scenario. Sound levels were undertaken in accordance with the standard methods detailed in the Approved Code

2 The Australian and New Zealand Standard Industrial Classification (ANZSIC) was developed by Statistics New Zealand and the Australian Bureau of Statistics to reflect the structure of Australian and New Zealand industries and improve the comparability with other countries' statistics.

of Practice for the Management of Noise (2002) and AS/NZS 1269, 1998: Part 1 Measurement and assessment of noise immission and exposure [17]. All sound level meters complied with the requirements of AS 1259.1 (IEC 60651) and/or AS 1259.2 (IEC 60804). Sound exposure meters and doseBadges complied with the requirements of IEC 601252. Reference sound sources (calibrators) complied with Class 2 specifications of IEC 60942. Where each workplace provided a range of sound levels, the median time average levels were included for analysis to account for outliers.

3.1. Noise sources, paths and controls

An analysis of noise sources and paths in the workplaces found that for the high risk industry sectors, the sources were primarily due to impact noise; rotational noise due to machinery, gears, conveyers and electric motors; engine noise; high frequency pneumatic noise due to hydraulic equipment and operations; pipe noise due to turbulent flow within pressurized steam lines; compressor noise and alarm noise due to operational alarm activation. For the medium and low risk sectors, noise sources tended to be related to the task, activity and equipment being used and the interaction of other, usually external sources of noise not directly related to the workplace such as traffic noise.

Identification of noise paths in relation to the noise sources was complex as it included indoor and outdoor environments. However, airborne paths were the primary route for noise, with some cases of structure-borne and duct-borne noise/vibration transmission. Agriculture, construction and saw milling sound sources and paths were similar in the fact that sound from many key activities, tasks and use of equipment and machinery were generated and transmitted in outdoor environments. This is opposed to the other traditional manufacturing sectors (bottling, textile, engineering) where key activities, tasks and machinery and equipment use were usually undertaken within a building structure (indoor), where structure borne sound transmission became more evident.

The predominant noise control strategy in the majority of organisations surveyed was that of protection specifically, the use of personal hearing protection. Of the 33 organisations assessed, twenty (20) had explored options for elimination and isolation of noise sources. Of those, only four businesses had undertaken modifications or replacement of equipment, which resulted in a self-reported reduction of noise exposure in the workplace. The remaining businesses (16) had not pursued these control options. Administrative controls were not used in any of the organisations surveyed.

3.2. Exposure to noise and personal sound exposure (dose) measurements

Table 1 summarises details of the workplaces' median $L_{Aeq,8h}$ and L_{Cpeak} levels, dose estimates and percentage of work areas equal to (=) or greater (>) than 85 dB. Of the "high" risk industry sectors, wood processing, sawmills, engineering manufacturing sites and construction operations experienced the highest time average levels with median $L_{Aeq,8h}$ values of 95 dB, 92 dB and 90 dB respectively. Median L_{Cpeak} levels were also high at 130 dB, 125 dB and 120 dB. Farms included in the agricultural sector surveys had median $L_{Aeq,8h}$ values of 85 dB, and median L_{Cpeak} level of 115 dB. The remaining high risk industry sectors surveyed (agriculture, bottling and textile industry) had median $L_{Aeq,8h}$ values of 85 dB, 83 dB and 80 dB, and median L_{Cpeak} level of 115 dB, 105 dB and 100 dB respectively.

Noise dose estimates for employees working in these businesses are detailed in Table 1, and indicate a very wide range of personal exposures (10-600 %), with wood processing and sawmills, engineering and construction operations experiencing the highest dose and widest dose range. The medium risk industry sector (hospitality, specifically cafes) surveyed had a median $L_{Aeq,8h}$ values of 74 dB, and median L_{Cpeak} level of 105 dB. Noise dose estimates for cafes employees ranged between 8-26 %.

The low risk industry sector (preschools) had median $L_{Aeq,8h}$ values of 70 dB, and median L_{Cpeak} level of 110 dB. However, the noise dose estimate ranges for employees working in preschools (4-98 %) was very large in comparison to café measurements. Two employees in preschool facilities had daily dose estimates of 194 % and 316 %. These values were outliers and were excluded from the analysis in Table 1.

3.3. Noise control conformance assessment

This assessment audited employers and employees responsibilities under the Health and Safety in Employment Act 1992 with respect to noise, utilising the Approved Code of Practice for the Management of Noise in the Workplace [16]. Data was collected through semi structured interviews, observational data and investigation of archival data and information. Conformance values ranged from 0 to 6 out of 10, with the median 2 and mean 1.9 (SD 1.7).

The conformance element most commonly addressed was the provision of personal hearing protection (element 6), followed by the requirement to investigate and if practical, control noise at source (element 4). A number (16 of the 20) did indicate that they had investigated control at source options, but had not pursued these options. The reasons most commonly given for not pursuing these was cost of putting in controls or replacement equipment and technical expertise on how to reduce noise further. Nine of the 33 businesses had undertaken some form of preliminary noise survey (element 2), although only 2 businesses could provide documentation that the surveys had been carried out. Five businesses indicated they had provided information on noise to employees (element 9) as part of their hazard management programme.

Table 1: Summary of sound levels and dose estimates of workplace surveys by industry sector

	Agriculture / Dairy	Manufacturing				Construction	Hospitality Cafes	Education Preschool
		Bottling	Engineering	Textile	Sawmills			
# workplaces	4	3	3	3	8	3	4	5
# work areas	9	10	10	6	10	6	10	10
Median $L_{Aeq,8h}$ (dB)	85	83	92	80	95	90	74	70 *
Median L_{Cpeak} (dB)	115	105	125	100	130	120	105	110
Dose range (%)	70 – 125	10 – 147	10 – 588	10 – 50	60 – 600	30 – 400	8 – 26	4 – 98 *
Median dose (%)	89	72.5	227	27	400	200	13	23 *
% work areas ≥ 85 dB $L_{Aeq,8h}$	55	30	80	0	90	66	0	0

* Range excludes recorded dose values for two subjects of 194% and 316% (outliers)

Less than 10 % of the businesses undertook audiometry of employees, isolated noise sources or had notified the Department of Labour of a hearing loss case (elements, 7, 5 and 8). As a consequence only two businesses were evaluated as taking all practical steps to provide a safe place of work.

With few exceptions, there was insufficient evidence that the key requirements of the Approved Code were being met. Noise tended to be identified as an issue by management and employees and some informal assessments were undertaken (e.g. difficulty having a conversation). Little evidence existed that noise was identified as a significant hazard, that is, preliminary noise assessments were undertaken.

There was some evidence that elimination and isolation strategies were explored to reduce noise exposure, but were not generally pursued or utilised. Administrative controls were not used in any of the organisations surveyed. There was substantial evidence that minimisation (use of hearing protection) tended to be employed as the key control strategy.

There was little evidence that information or training was provided for noise control/ management in the workplace. Similarly, there was little evidence that noise monitoring or audiometry was routinely undertaken in

the cases studied.

Mean conformance scores by industry sector were calculated and shown in Figure 1.

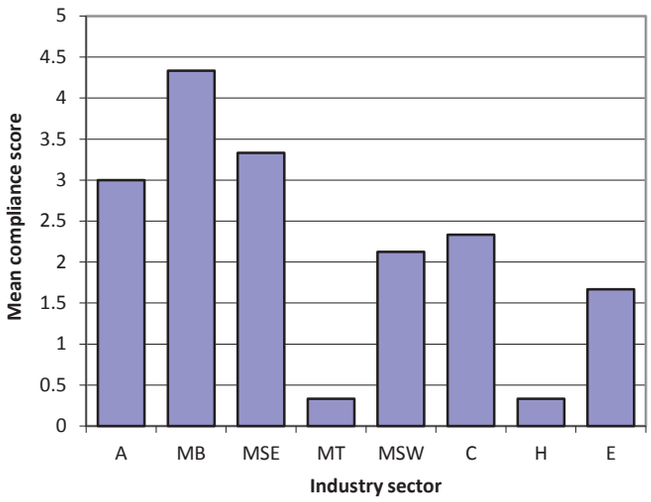

Figure 1: Mean conformance scores by industry sector

Key: A=Agriculture (n=4); MB=Manufacturing Bottling (n=3); MSE=Manufacturing Engineering (n=3); MT=manufacturing Textiles (n=3); MSW=Manufacturing Sawmills/Wood processing (n=8); C=Construction (n=3); H=Hospitality (n=4); E=Education (n=5).

Of the "high risk" industry sectors surveyed the bottling, engineering businesses and farms were the most compliant (mean (standard-deviation) conformance scores; 4.3 (2.1), 3.3 (2.3) and 3 (0) respectively). Construction and saw mill/ wood processing businesses had mean (standard deviation) conformance scores of 2.3 (0.58) and 2.1 (0.35) respectively. Of the remaining "high risk" industry sectors, textile manufacturing had the lowest mean conformance score of 0.33 (0.57), which was comparable with the "medium risk" hospitality sector (mean 0.33 (0.57)). The "low risk" sector, education, had a mean conformance score of 1.7 (1.5).

4. Discussion

4.1. Noise sources and paths

The noise sources and paths identified in this study are consistent with those identified in a range of surveys from a variety of traditionally noisy industry sectors (construction, agriculture, manufacturing, mining) and are primarily impact generated (metal on metal) and rotational components of engine and machinery operation [3,18,1,2,19,20,21]. The noise sources for specific pieces of equipment and operations/ tasks have also been reported.

Noise sources in agricultural work identified in this study are consistent with those identified in other studies and usually linked to specific equipment and tasks [1,2,19]. Sources included engines and gears, pneumatic and hydraulic noise, compressor noise and radio noise. It was suggested however [2], that the common and everyday sources of noise exposure in farming are not intense but because of this, the effects could be subtle and the onset of hearing loss insidious.

Noise sources in the manufacturing sectors in this study were extremely varied and very much dependent on the manufacturing process and machinery used in the process in a similar way to those identified by earlier studies [20,21]. The key feature of noise sources found in the manufacturing sectors was the relationship of the sound emission to an enclosed or semi-enclosed workspace (bottling plant, engineering workshop and textile factory). The sound fields in the workplaces were complex, due to the involvement of many sources including air-borne noise and structure-borne noise, reflections from the floors, walls, ceilings and machinery surfaces and absorption on surfaces. The basic mechanism of noise generation was due to mechanical noise, impact noise, fluid noise and/or electromagnetic noise.

The noise sources identified in the construction activities in this study were compatible with the categories identified by Hattis [3] and capture broad groups of problem types with different opportunities for abatement. Suter [18] suggests that controlling construction noise at the source is the most reliable way to protect worker hearing. United States (and New Zealand) manufacturers and contractors should benefit from the activities of the European Community, where noise control and product labelling in construction has been carried out for more than 20 years.

The noise sources in the cafés were consistent with those identified by Christie and Bell-Booth [22], including impact noise due to the banging of cutlery and crockery, mechanical/equipment noise from the operation of the till, appliances such as food processors and the coffee machine and fan and extractor noise. Other important sources of noise include traffic, patron generated and radio/music background noise. A large proportion of noise sources contributing to background noises were those associated with kitchen areas, especially coffee machines and grinders. These sources may contribute a great deal to the overall acceptability of the workspace.

Two principal sources of noise identified in the preschool centres surveyed included noise generated from the children and the activities they are engaged in, such as: music, and noise intrusion from outside activities; traffic and transportation noise sources. This is consistent with surveys undertaken by McLaren and Dickinson [23] and [24], where some activities and equipment were found to be especially noisy, indicating that controls on the level of noise for these were needed. This included some music sessions from amplified music and the use of percussion instruments such as claves. In addition, major construction work carried out in the vicinity of centres was another source of noise generated at the time of the survey and highlighted the influence of external sources on individual noise exposures.

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Rocker Dave Grohl has written a support letter urging British officials to lift a ban against a loud teen metal band.

Black Leaves of Envy were recently ordered by city council officials in Cornwall, England to keep their garage band practices around 30 or 40 decibels.

However, after receiving noise complaints, the council banned the group from playing completely and they have subsequently not been able to practice for the past three months, according to local newspaper the Plymouth Herald.

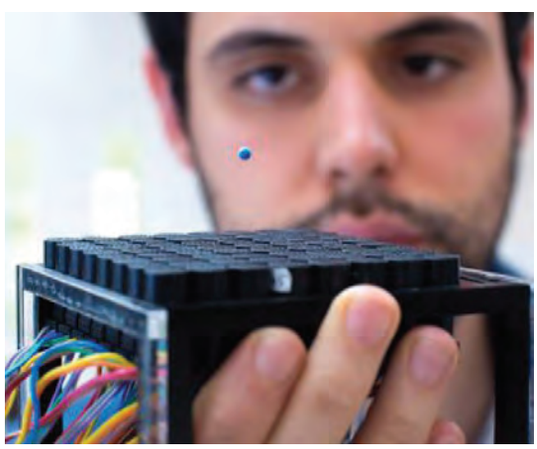
One of the young rockers' fathers, Andrew Plenty - a lead singer in his own rock band - tells the publication he launched a campaign to help garner community support in hopes of overturning the ban.

From science fiction to reality - sonic tractor beam invented

The world's first sonic tractor beams that can lift and move objects using soundwaves have been built by a team that includes researchers at the University of Sussex.

Tractor beams are mysterious rays that can grab and lift objects. The concept was created by sciencefiction writers but has since come to fascinate scientists and engineers.

Researchers at the Universities of Sussex and Bristol, in collaboration with Ultrahaptics (http://ultrahaptics.com), have now built a working tractor beam that uses high-amplitude soundwaves to generate an acoustic hologram that can pick up and move small objects. The technique, published in Nature Communications today (27 October 2015), could be developed for a wide range of applications. For example, a sonic production line could transport delicate objects and assemble them, all without physical contact. Or a miniature version could grip and transport drug capsules or microsurgical instruments through living tissue.



The researchers used an array of 64 miniature loudspeakers (driven at 40 kHz with 15Vpp. The whole system consumes 9 Watts of power) to create high-pitched and high-intensity sound waves to levitate a spherical bead (of up to 4 mm in diameter) made of expanded polystyrene.

See the Nature communications documentary: https://youtu.be/6hE6KjLUkiw

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In general, although many operations were complex, noise control strategies aimed at the noise source and noise paths could have been investigated further, including more specific and direct enclosure of machinery and equipment, use of vibration isolation, regular maintenance of machinery and equipment, elimination or replacement of old machinery and implementation of a "buy quiet" purchasing policy. Any noise control measure should be carried out after a source ranking study, using identification and quantification techniques.

4.2. Exposure to noise and dose measurements

The results of this study shows that of the "high risk" industry sectors surveyed, most had median sound levels that were at or above 85 dB $L_{Aeq,8h}$. These results are consistent with exposures reported by numerous researchers [3,20,25,2,26,27,21].

Median noise exposures recorded in "moderate" and "low risk" industry sectors (cafes and preschools respectively) were below 85 dB $L_{Aeq,8h}$ and also consistent with those reported in previous studies [23,24,22].

In addition, and possibly more significantly, although not obviously covered by the health and safety legislation, children can also be affected by excessive noise levels in early childhood centres. The recently enacted legislation requires that all reasonable steps are taken to promote the good health and safety of children enrolled in the centre or service [28]. Underpinning that, the Health and Safety Criterion No 15 [29] requires that all practicable steps are taken to ensure noise levels do not unduly interfere with normal speech and/or communication or cause any child attending distress or harm.

4.3. Noise control conformance assessment

The results of the compliance assessment in this study (range 0/10 to 6/10 with score 10 being fully compliant; median 2; mean 1.9 (standard-deviation 1.7)) provide disappointing evidence that businesses are not identifying, assessing or putting in place and supporting appropriate noise controls strategies for their industry sector. This contrasts the results of the Williams et al. [25] Australian study, where in 45 % of workplaces surveyed (n=113), managers reported that there was a noise control policy and 76 % of managers stated that a noise assessment had been conducted. In addition, 46 % were aware of the noise exposure standards and 47 % were aware of the code of practice. However, Williams et al. [25] noted that awareness of noise regulations and self-compliance was lower in small businesses (employing fewer than 20 people) compared to medium and large businesses. Approximately, 20 % of managers in small businesses were aware of the noise exposure standards and code of practice, compared with 62 % in medium and large businesses. This was not the case with the New Zealand workplaces surveyed in this study.

However, some results of this study are also consistent with those of Williams et al. [25] in that it was found that industry in general tends to be heavily reliant on the use of hearing protective devices (HPDs) for exposure control. Moreover, small businesses place more reliance on the use of HPDs and much less reliance on hazard control using structured programme involving engineering, administrative and maintenance controls [25]. These issues have been extensively reviewed in the wider OHS context [30].

As the owner-manager is the key person in the small enterprise, it is their values that determine the businesses approach to health and safety management. Many owners however, consider health and safety to be the employees' responsibility and often are not aware of legislative requirements [30]. This has the effect that compared with large and medium sized businesses, small businesses appear to be less aware of noise exposure standards, and less likely to have noise management policies or to have undertaken sound level surveys. This was evident in the findings of the present study where few managers of the small businesses were aware of any specific occupational noise exposure standards.

A lack of financial resources in small businesses is also important from an OHS intervention perspective, as paying for health and safety advice, information, tools and controls will always be implicitly or explicitly evaluated by a cost-benefit analysis [31]. Tight budgetary constraints often mean that there is a lack of financial resources to implement health and safety initiatives, such as noise surveys, the installation of engineering controls or personal protective equipment. Economic incentives are therefore an important encouragement for small businesses to improve health and safety practices generally [32].

In the United Kingdom (UK), Wilson [33] reports that there have been significant changes in Health and Safety Executive (HSE) (the equivalent of Worksafe NZ) expectations with respect to policing the requirements of the UK noise regulations. The emphasis is now on noise control, and it is mandatory to evaluate the options to reduce noise levels. This means that protective hearing devices are not an "acceptable long-term solution unless noise control can be shown to be impractical". In this risk based approach, there is a much stronger duty to reduce noise by engineering means. Risk assessments should identify a programme of work where there is less emphasis on assessment and "process" and more on action. If solutions have been identified - "stop assessing and start controlling". Health surveillance is required above time weighted average levels of 85 dB L_{Aeq}, which can be considered to be - "a tax on failure to control the

risks". This approach by the HSE has yet to be evaluated but highlights the conceptual shift from a "protection" to a "prevention" focus on noise management. Similarly, Williams et al. [25] suggests that the approaches that could be adopted to achieve better compliance within the small business sector (e.g. regulatory enforcement, or an assistive and educational approach) need to be determined.

5. Conclusions

Generally noise sources and paths could be readily identified in the workplaces and were consistent with those identified in a range of surveys from a variety of traditionally noisy industry sectors (construction, agriculture, manufacturing, mining). These noise sources are primarily impact generated (metal on metal) or come from rotational components of engine and machinery operation.

The noise sources in the moderate and low risk industry sectors (hospitality and education) were due to mechanical/equipment noise from the operation of appliances, person generated noise (patrons and children respectively), and sources of noise intrusion from outside activities (e.g. traffic and transportation noise sources).

The predominant noise control strategy in the majority of industry sectors surveyed was that of minimisation, specifically the use of hearing protection. Although many operations were complex, noise management strategies aimed at the noise source and noise paths could have been investigated further. In agriculture and construction, however, prevention through either noise reduction at source or isolation of the noise, even though best practice, may not always practicable so that hearing protection could be the only control option available. Administrative controls were not used in any of the organisations surveyed.

There was evidence that businesses are not identifying, assessing or putting in place and supporting appropriate noise management strategies for their industry sectors. It was found that industry in general tends to be heavily reliant on the use of hearing protective devices (HPDs) for exposure control. Moreover, small businesses place more reliance on the use of HPDs and much less reliance on hazard control using structured programme involving engineering, administrative and maintenance controls. Compared with large and medium sized businesses, it was found that small businesses appear to be less aware of noise exposure standards, and less likely to have noise management policies and to have undertaken sound level surveys.

This study supports evidence that there needs to be significant changes in expectations with respect to policing the requirements of noise legislation. The first (and sometimes only) strategy in the management of noise is to adopt the use of hearing protection devices. This is not an acceptable solution unless in working through the formal risk management process, this is found to be the only practical solution.

In the new Health and Safety at Work Act 2015 and the pursuant Health and Safety at Work (General Risk and Workplace Management) Regulations 2016, the principles of managing risk have been significantly strengthened. The Act prescribes a duty to eliminate risks as far as reasonable practicable and if not possible, risks are to be minimised far as reasonable practicable. To implement control measures to minimise risk, the above regulations prescribe the following five steps:

(a) substitution (wholly or partly) with something that gives rise to a lesser risk

(b) isolating the hazard giving rise to the risk to prevent any person coming into contact

(c) implementing engineering controls

(d) if risk remains – implement administrative controls

In addition, national strategies on the prevention of NIHL need to be designed from a small business perspective

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where noise management interventions are seen as a benefit to the enterprise rather than a cost.

6. References

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