2016

Does Perception equal Protection? Occupational Noise Exposure & Hearing Protective Device Utilisation for Engineering Trades

David A. Corbett
Field Enviro

Jane L. Whitelaw
University of Wollongong, jwhitela@uow.edu.au

Publication Details

Corbett, D. A. & Whitelaw, J. L. (2016). Does Perception equal Protection? Occupational Noise Exposure & Hearing Protective Device Utilisation for Engineering Trades. Australian Institute of Occupational Hygienists 34th Annual Conference (pp. 43-53).

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Keywords

does, perception, equal, occupational, trades, protection?, engineering, utilisation, device, hearing, &, exposure, noise, protective

Disciplines

Education | Social and Behavioral Sciences

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DOES PERCEPTION EQUAL PROTECTION?

OCCUPATIONAL NOISE EXPOSURE & HEARING PROTECTIVE DEVICE UTILISATION FOR ENGINEERING TRADES

Authors: DA Corbett (Field Enviro) & JL Whitelaw (University of Wollongong)

Abstract

The study examined exposure trends amongst a specific cohort of workers (n=55), loosely defined as "engineering trade" employees, but essentially comprising fitter and boilermaker trade disciplines at a variety of workplaces (n =6). Workers' perceptions of their noise exposure was surveyed, and factors likely to influence positive or negative HPD use behaviours. The goal being to identify determinants of Hearing Protective Device (HPD) use behaviour and potentially apply targeted interventions to increase the efficacy of a workplace's Hearing Conservation Program (HCP).

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The research concludes that a mandatory HPD use policy is an essential element in predicting positive HPD use behaviours to ensure exposure control.

Introduction & Background

A comprehensive review of Occupational Noise-Induced Hearing Loss (ONIHL) by Safe Work Australia (2010) concluded that very few wide ranging studies on the extent and distribution of noise exposures within Australia have actually been conducted. The agency notes that the former Australian Safety & Compensation Council (ASCC) concluded during 2001-2 that approximately 10.5-12% of the Australian working population was exposed to excessive noise (i.e. >85dB(A)) L_{Aeq8hr} .

Safe Work Australia (2014) occupational disease indicators show a recent increase in compensable ONIHL claims in Australia. After remaining steady around the 400 claims per million employees rate for the first half of the decade claims had increased markedly to more than 500 claims per million employees for the 2008-11 period.

Anecdotal evidence about noise control programs has long framed a certain bias towards a "HPD first" approach to exposure control. A study by Daniell et al (2006) of 76 US workplaces indicated that since the inception of OSHA noise regulations 20 years prior, most workplaces reported little if any implementation of source or transmission noise controls, with a strong bias towards the use of HPD's as a "first and only" control. Of those workplaces surveyed HPD utilisation rates were reported at only 38% for confirmed excessive noise environments.

Neither the ready availability of HPDs, nor the instruction for their use, are absolute guarantees that workers will use them. Studies by numerous researchers (Lusk et al 1994, Lusk et al 1998, Edelson et al 2009, Oisaeng et al 2011, and Arezes & Miguel 2006) have examined levels of hearing protector use in various occupational cohorts, as well as factors that may be significant determinants and predictors of HPD use.

A majority of the aforementioned studies that address factors likely to influence HPD utilisation are based on Pender's (2006) Health Promotion Model (HPM) originally proposed in 1982, and revised in 2006 (see Figure 1). The model proposes that a health promoting behaviour (such as the adoption of HPD) is the result of a series of defined factors acting in concert or competition to yield that behaviour.

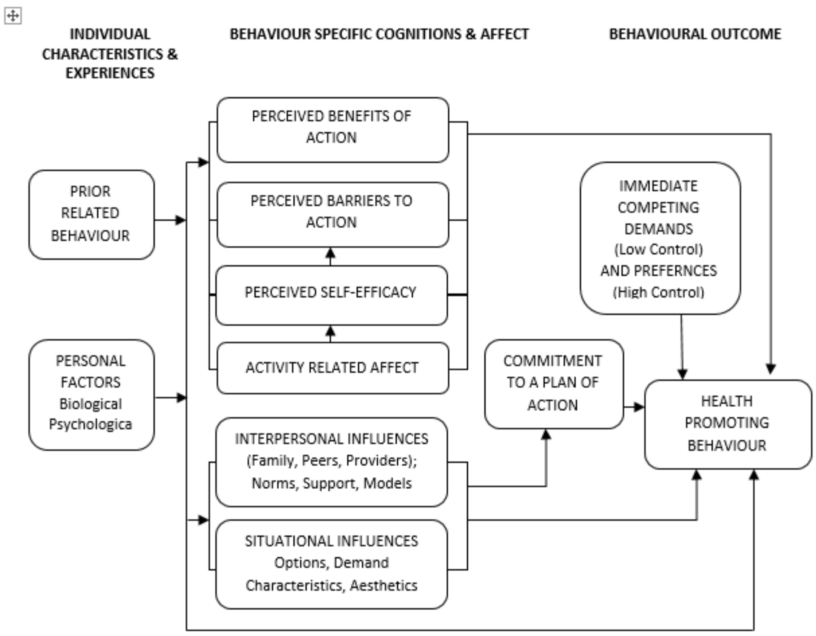


Figure 1 – Health Promotion Model (as revised). Source: Pender et al (2006)

Research Objective

The aim of the study was to examine noise exposure within a particular occupational group, namely engineering workshop employees from fitting and boilermaker trade disciplines; to establish the following;

- The likelihood of worker noise exposures typically exceeding acceptable noise exposures, as defined by regulation, with the potential to result in ONIHL;
- The extent to which workers can correctly predict their exposure risk as "acceptable" or "unacceptable";
- HPD utilisation behaviours and factors that may typically influence or predict the likelihood of correct behaviours occurring.

Exposure Criteria

All participating workplaces were based in Queensland and subject to regulatory L_{Aeq8hr} requirements pertaining to occupational exposures to noise mandated by either *Work Health & Safety Regulation 2011* (Qld) or *Coal Mining Safety & Health Regulation 2001* (Qld).

Both of the aforementioned regulatory instruments prescribe that workers' exposure to noise is kept to an acceptable level and the worker is not exposed to noise levels exceeding the levels stated in the Safe Work Australia *National Standard for Occupational Noise* [NOHSC: 1007]. Excessive noise as defined by the Standard is a level of noise above an 8 hour equivalent continuous A-weighted sound pressure level (L_{Aeq8hr}) of 85dB(A) and a C-weighted peak sound pressure level exceeding 140 dB(C). Adjustments to normalized 8hr noise exposure level for extended work-shifts were made for participating workplaces/employees working shifts of ≥10 hours duration as required by AS/NSZ 1269.1.

Principal consideration has been given to L_{Aeq8hr} exposures for the purposes of the current project as the principal exposure measure in relationship to the potential development of an ONIHL for an engineering trade worker over the working life of that tradesperson from chronic exposure.

Methods

The study was conducted utilising a mixture of quantitative, semi-quantitative, and qualitative data collection techniques aimed at characterising noise exposure within the sample group, and understanding HPD utilisation rates and potential determinants within a sample group (n=55). Workers participating in the project were from separate workplace sample groups (n=6), and from one of two distinctly categorised "engineering trade" disciplines – (i) boilermakers (n=33), and (ii) fitters (n=22). All participants were fully trade qualified personnel (no apprentices).

Quantitative Exposure Evaluation Techniques & Exposure Characterisation

Occupational noise exposure assessments were performed with reference to measurement principles outlined in Australian Standard AS/NZS 1269.1 - *Occupational Noise Management - Part 1: Measurement and assessment of noise immission and exposure*. Noise dosimeters were used to monitor noise exposures for selected study participants. Noise dosimetry was performed over representative monitoring periods (exceeding 90% of total shift duration in all instances).

The following equipment was used to conduct the survey:

- 10 x Casella 35X Personal Exposure Noise Dosimeters – Type 2 Devices. (SN:2039003 - 2039012);
- Svantek SV-30A Type 1 Acoustic Calibrator – (S/N: 19472).

Personal exposure meters used conform to those meters referenced for operation in AS/NZS 1269.1. The acoustic calibrators in use was within a current NATA calibration periods at the time of assessments. All personal exposure meters were within their initial 2 year Casella Original Equipment Manufacturer (OEM) factory calibration period at the time of assessments. All devices were field checked against the NATA certified field calibrator for accuracy prior to and immediately after measurement. Deviations of more than ±0.5dB were not observed during field calibration and checking.

Results of personal noise dosimetry (L_{Aeq8hr}) were inputted the American Industrial Hygiene Association (AIHA) IHSTAT+ Similar Exposure Group (SEG) spreadsheet package (as linear pascal inputs) to confirm sample distribution trends and the likely presence of one or more SEGs. A further ANOVA was performed to confirm the statistically significant variance ($p=<0.01$) between two identified SEGs groups – fitters and boilermakers.

HPD Utilisation Questionnaire

A HPD Utilisation Questionnaire was constructed with the aim of assessing the rate of HPD utilisation within the sample group and establishing potential significant predictors of HPD utilisation behaviour. The questionnaire also sought to assess workers' perceived risk of noise exposure against their actual noise exposure, and the accuracy of this judgement.

The questionnaire was largely structured upon the Pender (2006) Health Promotion Model (HPM) as depicted in Figure 1. Previous researchers (Lusk et al. 1998; Oisaeng et al. 2011) had constructed study questionnaires based on the HPM, however none of the actual questionnaire instruments were published. In lieu of access to a previously utilised or validated questionnaire researchers set out to construct a questionnaire based on HPM factors and other selected factors as possible independent variables influencing the dependent variable (HPD use behaviour). These factors are detailed following;

Individual Characteristics				
Age	Trade	Years Trade Experience	Perceived Hearing Acuity	Perceived Risk
Behaviour-Specific Cognitions & Affect – HPM Factors				
Interpersonal Influence	Situational Influence	Perceived Benefits of HPD Use	Perceived Barriers to HPD Use	Perceived Self-Efficacy of HPD Use

Behavioural Outcomes relating to HPD usage were assessed utilising 4 questionnaire items. Variables were also based on a 5-point Likert psychometric scale (ordinal) assessing the worker's self-reported incidence of a HPD use behaviour from "Never" to "Always".

HPD Questionnaire results were manually collated and entered into the IBM SPSS Statistics v. 20.0.0 program for coding and analysis. Statistical analysis techniques applied included dimension reduction (through exploratory and confirmatory factor analysis), and multiple regression analysis.

Factor analysis techniques were chosen to attempt to firstly confirm the efficacy of the questionnaire design in relation specifically to Pender's (1996) HPM model factors, and further examine the potential significance of factors on HPD use behaviours (behavioural outcomes). A single behavioural outcome was confirmed and subjected to regression analysis utilising independent variable factors derived from both HPM model factors, and individual characteristics factors previously identified. Further regression analysis was also performed for HPM factors only in isolation.

Results

Exposure Measurement

A SEGs data summary including current assessment data for fitters, boilermakers, and all workers combined is detailed in the following Table 1. Highlighted cells indicate excessive values as compared against the L_{Aeq8hr} regulatory limit. To further verify the presence of proposed SEGS a one-tailed ANOVA test was performed, which confirmed the between groups mean exposure difference (fitters vs. boilermakers) to be very significant (p=<0.01).

Table 1: Summary Results - Comparative SEGs Analysis

DESCRIPTIVE STATISTICS	Fitters	Boilermakers	All Workers
Number of samples (n)	22	33	55
Maximum (max)	92.3	105.5	105.5
Minimum (min)	79.3	85.7	79.3
Percent above OEL (%>OEL)	77.3	100.0	90.9
Mean	87.3	95.3	92.9
Median	87.0	94.5	90.9
TEST FOR DISTRIBUTION FIT			
Normal (a = 0.05)?	Yes	Yes	No
NORMAL PARAMETRIC STATISTICS			
$LCL_{1,95\%}$ - t statistics	86.2	93.7	91.4
$UCL_{1,95\%}$ - t statistics	88.2	96.8	94.3
95th Percentile – Z	91.0	101.3	99.8
UTL95%,95%	92.2	102.6	101.0

Further descriptive results are presented subsequently. Figures 2.1-2.3 indicated the total proportion of the "all workers" sample group reported an excessive (>85dB(A)) exposure by dosimetry for all samples was 92%. All (100%) sampled boilermakers recorded L_{Aeq8hr} exposures >85dB(A) compared to 77% of fitters sampled.

Figure 2.1 - % Fitters exposed to excess noise

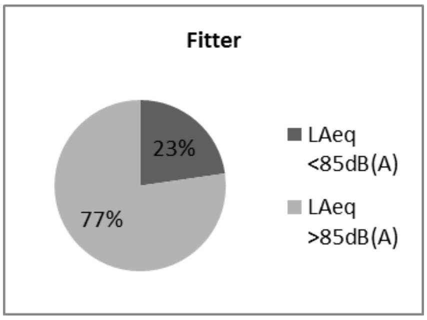


Figure 2.2 - % Boilermakers exposed to excess noise

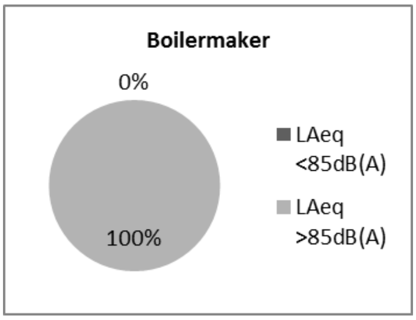


Figure 2.3 - % Total Workers exposed to excess noise

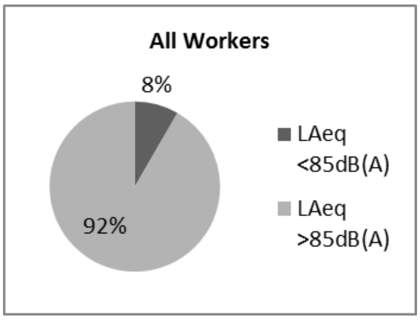
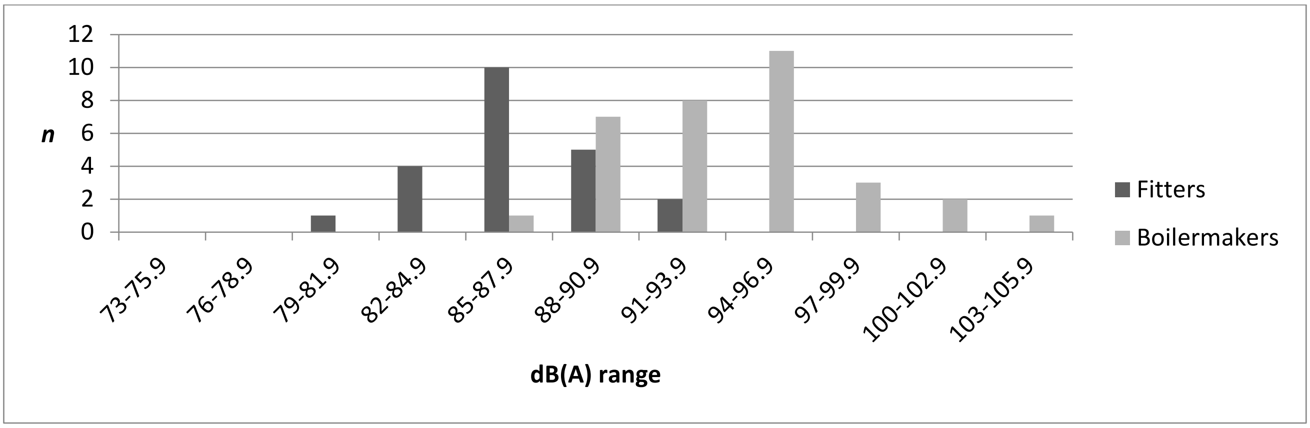


Figure 3 represents exposure frequency distribution for both boilermaker and fitter sample groups. The distribution has been modelled at ±3dB about the 85dB(A) regulatory exposure limit to reflect the 3dB exchange rate assumption (i.e. noise dose is doubled in 3dB(A) increments). The distribution appears to depict a binomial structure (which shall be discussed subsequently in SEGs analysis). Boilermakers appear to generally exhibit greater average noise exposures than their fitter counterparts.

Figure 3 – Distribution of L_{Aeq8hr} noise exposure by trade discipline



Figures 4.1 and 4.2 depict distribution of correct to incorrect exposure predictions (i.e. risk perception) as reported by workers at the end of their dosimetry periods. All (100%) of boilermakers were able to correctly predict their overexposure. Fitters were less able to accurately predict their overexposure, with more than half (6/10 sample cases) in the 85-87.9dB(A) exposure range able to correctly predict their overexposure.

Figure 4.1 - Fitters – Correct vs Incorrect Noise Exposure Prediction

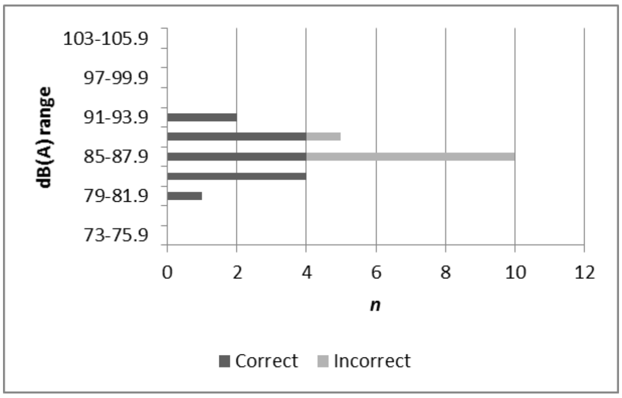
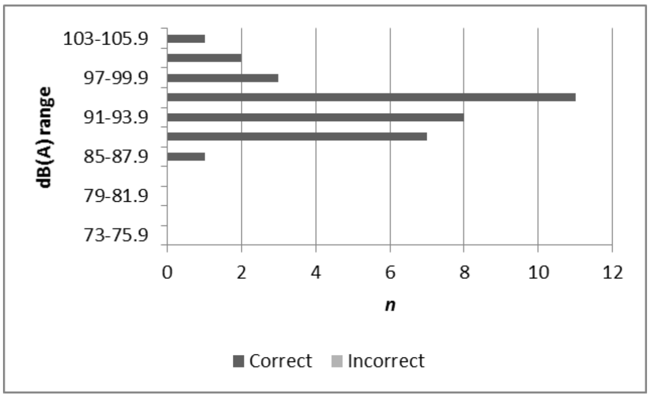


Figure 4.2 - Boilermakers – Correct vs Incorrect Noise Exposure Prediction



HPD Utilisation Questionnaire

All 55 administered questionnaires were returned. Missing data/items were not reported and all questionnaires were incorporated for study analysis. Confirmatory Factor Analysis (CFA) was performed on questionnaire data for results comparison against Pender's HPM Behaviour-Specific Cognitions & Affect factors. Most HPM factors were confirmed during CFA (albeit with KMO <0.6 indicating reduced sampling adequacy), however two factors performed poorly and were restructured prior to input into regression analysis.

Results of multiple regression analysis performed for all study factors is detailed in Tables 2 & 3 below. Initial analysis incorporating essentially all study factors (Table 2) found Hearing Protection Policy (p=<0.01) and Years Trade Experience (p=0.02) to be significant predictors of the combined HPD use behavioural outcome factor.

Table 2 – Multiple Regression Analysis –HPM & Individual Characteristic Factors

Coefficients[a]

Model (Factor)		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
	(Constant)	-3.039	.989		-3.074	.004
	Interpersonal Influences Factor 1	.156	.120	.156	1.297	.202
	Situational Influences Factor 1	.092	.088	.092	1.047	.301
	Situational Influences Factor 2	-.015	.083	-.015	-.184	.855
	Perceived Benefits Factor 1	.132	.090	.132	1.472	.148
	Perceived Barriers Factor 1	.099	.106	.099	.930	.358
1	Perceived Self Efficacy 1	.021	.089	.021	.230	.820
	Mandatory HPD Policy	1.845	.409	.656	4.514	.000
	Actual_Exposed	-.166	.342	-.048	-.485	.630
	Exposure_Perception	.194	.259	.081	.751	.457
	Age	.060	.031	.497	1.953	.057
	Years Experience	-.065	.027	-.526	-2.404	.021
	Perceived Hearing Acuity	.130	.298	.051	.436	.665

a. Dependent Variable: BehavFac1 (i.e. Reported Use of HPD)

Analysis incorporating Pender's (2006) HPM factors only (Table 3) did not yield any significant predictors of the combined HPD use behavioural outcome factor. However, the interpersonal influences factor did emerge as the best predictive factor ($p=0.096$) amongst all HPM factors by a considerable margin.

Table 3 – Multiple Regression Analysis –HPM Factors Only

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	.261	.091		2.881	.006
	Interpersonal Influences Factor 1	.208	.122	.274	1.704	.096
	Situational Influences Factor 1	.048	.085	.089	.570	.572
1	Situational Influences Factor 2	.045	.094	.075	.484	.631
	Perceived Benefits Factor 1	.057	.089	.101	.635	.529
	Perceived Barriers Factor 1	.036	.116	.051	.312	.756
	Perceived Self Efficacy 1	.100	.085	.191	1.173	.248

a. Dependent Variable: BehavFac1 (i.e. Reported Use of HPD)

Discussion

Exposure Characterisation

Mixed results were found regarding the initial research objective of establishing the overall likelihood of an "engineering trades" cohort being exposed to excessive. Sample groups of both boilermaker and fitter trade disciplines typically manifested L_{Aeq8hr} exposures that exceeded the 85dB(A) regulatory exposure limit. There was, however, a clear binomial distribution trend in reported exposure data, confirmed through SEGs analysis and ANOVA, indicating the initial characterisation of an overall "engineering trades" SEG by the researchers is likely incorrect and that the sample group is best defined as comprising 2 separate SEGs based on fitter and boilermaker trade disciplines.

Despite the apparent exposure intensity differences between boilermaker and fitter trade disciplines, and the failure to establish a homogenous SEG, the results of dosimetry sampling, observations made during (and the results of area sampling), do indicate there is a likelihood of L_{Aeq8hr} exposures exceeding the 85dB(A) regulatory exposure limit during typically representative work activities for all sample group workers. Based on such characterisations, there is an evident requirement to implement exposure controls to ensure otherwise unprotected workers are not at risk of ONIHL through chronic exposure to noise over their working lifetimes.

Noise Exposure – Accuracy of Risk Perception

Results for the questionnaire item asking workers to nominate post-shift "*whether or not they believed they were exposed to excessive noise*" indicated that fitters, in particular, within an 85-88dB(A) exposure range were poor predictors of their excess exposure. This range also happens to reflect the expected mean and 95% confidence range determined for fitter SEG noise exposure in the sample group. In contrast, boilermakers were much better predictors of their excessive noise exposure with 100% of sampled workers correctly reporting a perceived excessive exposure. As previously mentioned the boilermaker sample groups reported a much higher mean and 95% confidence range, approximately 94-97dB(A).

It is contended by the researchers that there are two key reasons as to why fitters predicted their overexposure in the 85-88dB(A) range poorly. Firstly, as previously mentioned, as many as six fitters required extended shift adjustments that took their exposure from sub-85dB(A) L_{Aeqt} levels to final exposures in the 85-88dB(A) range. The AS1269.1 adjustment method is contrived on principles that on face value bear little relation to human perception of noise. Initially, normalisation of noise exposure essentially involves the "compaction and repackaging" of a 12 hour sound pressure level into an 8 hour equivalent. Furthermore, the addition of a +1dB adjustment to cater for reduced hearing mechanism recovery time does not reflect an actual "experienced" acoustic energy. To this end, workers are perhaps at a -2.8dB(A) perceptual disadvantage (based on a 12 hour shift normalisation and adjustment) before the next proposed reason is accounted for – loudness.

The loudness of sound is the key input with regards to how an individual experiences and hears noise as processed by the hearing mechanism. Yet research has shown an individual's subjective response to changes in sound pressure level does not precisely align. Lamancusa (2000) relates that an increase of 3dB to sound is only barely noticeable to the listener, and that change is not typically clearly noticeable to the listener until an approximate 5dB increase has occurred. In terms of the decibel scale and an assumed 3dB exchange rate, at 5dB noise exposure has more than doubled in terms of acoustic energy.

In total, based on the aforementioned two reasons, a worker on a 12 hour work shift could be at a perceptual disadvantage somewhere in the 7-8dB(A) range from the likely measured and adjusted noise exposure, making it somewhat difficult for workers to correctly predict their excessive noise exposure around the 85dB(A) regulatory criterion limit. Whereas, for boilermakers with much higher average exposures, the increased and perceivably high loudness of their exposure makes their judgement of excessive noise more well-defined.

Other factors are also suspected as potential determinants of fitter's poor predictive abilities as compared to their boilermaker counterparts. Background noise measurements were not obtained for all workshop settings, but for the two monitored fabrication workshops where 80-85dB(A) background noise measurements were recorded there were a number of indirect noise sources present within the workshop (e.g. grinding, needle gunning, hammering) at any given time. The lower recorded background noise for workshop six is seemingly the result of less indirect noise contribution. Indeed, in this instance between the performance of more isolated noise tasks (e.g. torqueing up bolts with an air wrench, hammering a pinion) there was much less background noise, in fact the workshop was perceivably quiet.

It is postulated that where, for fitting tasks, background noise levels are lower, and task duration with noisy tooling lower, than those recorded for boilermaker workshops, there is perhaps greater potential to discount the cumulative exposure effects of utilising noisy tooling by the operator. As this study did not collect specific and accurate task duration times it is not however possible to quantify the potential predictive power of these variables.

HPD Utilisation

The institution of a mandatory hearing protection policy ($p = <0.01$) was determined to be the most significant positive predictor of self-reported HPD use by study workers. Workers at workplaces with mandatory hearing policies almost universally reported positive HPD use behaviours, whilst such behaviours at the one study workplace with an elective HPD use policy (workplace six) were mixed to negative.

Years trade experience was a negative predictor ($p= 0.02$) of reported HPD use. This effect may have been exacerbated or pronounced by a number of workers at workplace six having long term trade experience reporting no HPD use, as face examination of trade experience vs HPD use data for remaining workplaces shows no discernible relationship. Removal of workplace six data from regression analysis resulted in the elimination of this effect ($p = 0.28$).

Incorporation of Pender's (1996) HPM factors only for regression analysis failed to yield any significant predictors of HPD use behaviour, however the strongest predictor by some margin were interpersonal factors ($p = 0.096$). Items comprising this factor addressed how workers perceived HPD use by other worker colleagues, supervisors and management as either positive or negative. So results may tend to indicate a degree of "modelling behaviour" influence in the decision of workers as to whether or not to use HPDs.

Despite potential construct validity issues with the survey instrument researchers were curious as to why all but essentially one of Pender's (1996) nominated modifying factors (i.e. interpersonal factors) had reasonably weak predictive value whilst other researchers had managed to establish stronger, significant and more numerous HPM predictive factors.

It is noted that many of the previously research studies, such as Oisaeng et al (2011) and Lusk et al (1998), incorporated study cohorts such as firefighters and construction workers from multiple work locations. The mandated requirement to wear hearing protection is not explicitly referenced by these studies and it is possible that HPD use for many of these participants was based on an elective basis. If this was the case, then with reference to the HPM, the researchers suggest that the effect of modifying factors (e.g. perceived benefits, barriers, self-efficacy) is likely to be more pronounced.

With reference to the current study, the majority of sampled workers were at workplaces where a mandatory hearing protection policy was instituted. In the HPM this could be considered an "immediate demand" as an external rule has been placed on the individual – i.e. they must wear hearing protection. As previously mentioned, a very significant ($p=<0.01$) predictive relationship was established for HPD use based on hearing protection policy (i.e. mandatory or not mandatory).

The researchers contend that it is highly likely in the absence of the previously referenced "immediate demand" of a mandatory hearing policy, HPD utilisation rates may drop significantly as workers elect to exercise their own decision making power and execute their own intended "plan of action" – i.e. not to utilise HPDs.

In summary, it is asserted that whilst a number of individual characteristics and behavioural and cognitive factors affect workers' likelihood of engaging in HPD use, this is mitigated by an external mandatory requirement to wear HPD (where instituted). The researchers assert this further underscores the responsibility of the employer at any given workplace to establish whether or not excessive exposures are likely through formal exposure assessment (i.e. occupational noise survey), and should exposure reduction be achieved by no other means than HPDs, that the use of those HPDs is formally mandated and supported by a well implemented HCP including selection and availability of appropriate HPDs, and training, instruction and enforcement of HPD use.

Limitations & Conclusion

General Study Limitations

A likely sizeable degree of selection bias is suspected by the researchers. As previously mentioned, five of six participating workplaces were assessed not only for the purposes of research, but as part of a commercial consulting arrangement. In essence, these participating workplaces "self-selected" their participation as convenience sample groups. Also, on this basis these workplaces demonstrated a degree of hazard/risk awareness at the workplace by actually seeking out and engaging a consultant to conduct a noise assessment and evaluate/recommend controls to ensure their legislative compliance. These workplaces were also larger workplaces employing more than 50 employees. The exception to the aforementioned considerations was workplace six, which was a smaller workshop (<15 employees), that the researchers actively sought out for study participation.

The researchers believe that workplace size may be a significant predictor of both overall control implementation, and also HPD utilisation rates. Given the likely large number of small engineering enterprises across Australia employing less than 50 workers, the current study would probably under-represent these workers in the cohort overall, and potentially positively bias HPD utilisation rates.

Future and better resourced research should perhaps seek to incorporate a greater proportion of smaller workplaces to better reflect workplace size distribution for the study cohort.

Exposure Characterisation Limitations

Personal dosimetry was conducted for only one shift period at each participating workplace (except for 1 workplace). Hence, there is no basis for comparison to determine whether exposures fall within historical mean exposure ranges for the workplace. Instead exposures can only be considered representative of the actual conditions and work activities conducted on the monitoring day.

The researchers did anticipate a high degree of noise exposure variability for workers due to the nature of the noise environments in engineering workplaces which are not typically subject to steady state noise sources from fixed plant. Rather engineering workshops are typically characterised by intermittent high intensity noise from portable plant, where the overall reported daily exposure to noise may vary markedly dependent on the duration and repetition of plant use.

HPD Use Determination Limitations

A degree of self-reporting bias is assumed, in particular with regards to HPD questionnaire items relating to HPD use behaviours. Despite the questionnaire being confidential, the researchers believe that many workers may still be likely to report positive/compliant HPD use behaviours – especially for sites where a mandatory HPD use policy is enforced. The desire to "say the right thing" may outweigh the compulsion to report negative/non-compliant behaviour. The researchers had no means to individually verify the accuracy of worker's responses through direct and continuous observation of HPD use in most cases due to simultaneous dosimeter deployment across workshops and project sites.

With greater time allowance and resources, the researchers could have spent more time refining the HPD questionnaire. As previously indicated, a standard and previously validated questionnaire based on Pender's (2006) HPM model was not available. Some questionnaire items statements such as "I like wearing hearing protection" (for the perceived benefits of HPD use factor) did not align well to other questionnaire item statements for the factor, when subjected to Confirmatory Factor Analysis (CFA).

The limited number of sample cases (n=55) and limited number of questionnaire items detailed for each factor also had implications for HPM factor validation in the questionnaire. Indeed, initial exploratory factor analysis of independent question variables was only able to yield 2 factors in total before maximum iterations for the factor analysis function was exceeded, an implicit indication of the requirement for a larger study sample group.

Conclusion

Research findings confirm the likelihood of excessive exposure, above the L_{Aeq8hr} regulatory criterion limit of 85dB(A), for the sample group, but in the form of two distinct SEGs aligning to boilermaker and fitter trade disciplines. Fitters exposed to L_{Aeq8hr} exposures in an 85-88dB(A) range were shown to be particularly poor predictors of their overexposure.

Engagement in positive HPD use behaviours was significantly aligned to the presence or otherwise of a mandatory hearing protection policy. Of Pender's (2006) suggested Health Promotion Model (HPM) factors, interpersonal influences (i.e the modelling and perceived use of HPD by other workers, supervisors, and management) at the workplace proved the strongest, yet not significant HPD use predictive factor.

Future research could improve on the deficits in research design encountered during the current study, such as improvement of the construct validity of the HPD utilisation questionnaire and increasing the total sample size and number of participating workplaces to account for the greater exposure variations and levels of HCP implementation anticipated across wider industry.

The researchers wishes to acknowledge and thank the workers and workplaces that have participated in the current study, and their demonstrated commitment to understand and protect workers from harmful exposures to noise at work.

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