Noise Exposure in the Australian Workforce

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ABSTRACT

This paper presents a new methodology for the estimation of the number of noise exposed workers Australia. Previous methods relied on the statistics from the annual rate of application for workers' hearing loss compensation claims, both successful and unsuccessful; the generalisation of small scale surveys to the broader population; or larger scale telephone surveys. This new method relates measured noise exposure data from sampled industries to official demographic data on the numbers employed in the respective industries. From Australian data it is estimated that around 20.1% of the workforce regularly work in noise above the recommended Exposure Standard ($L_{Aeq,8h}$ = 85 dB) and 9.4% above and exposure of 90 dB. These figure lie within the range of estimates indicated using other methodologies.

INTRODUCTION

Excessive noise is considered to be a workplace hazard and workplace noise exposure is one of 67 risk factors considered to significantly contribute to the Global Burden of Disease (GBD) (Lim, et al: 2012).

The World Health Organization (WHO: 1980) has emphasised noise exposure as a hazard for several decades and an International Standard exists for estimating the population risk of hearing loss from noise exposure (ISO 1999: 1990). For continuous noise, exposure is a function loudness (L_{Aeq}) and time. For hearing loss purposes the exposure time is usually measured in years. In practical terms, only a small percentage of those exposed will demonstrate any significant permanent threshold shift for exposures less than ten years.

In Australia the initial estimates of the number of individuals exposed to hazardous noise came through claims for noise-induced hearing loss (NIHL) or noise injury (NI) lodged annually with State, Commonwealth and Territory workers' compensation schemes. The first attempt for a nation-wide estimate of hearing loss due to noise exposure was by the Australian Bureau of Statistics (ABS: 1978a) which reported about one quarter of the 780,000 Australians who suffered *"some degree of hearing loss" attributed their impairment to the effects of 'constant noise'"* (Waugh 1986, p 2).

The next attempt was in 1991 when an estimate suggested that up to 0.5 million people in Australia worked in hazardous noise environments exceeding the, now current, exposure Standard ($L_{Aeq,8h}$) of 85 dB (p 17, Waugh: 1991). This estimate was drawn from retrospective compensation claims data and some basic questions addressed in two Australian Bureau of Statistics surveys (ABS: 1978b; 1988) from questions along the lines of *'do you have trouble hearing what people say'*.

More recently Safe Work Australia (2010) conducted a nationally representative survey of the Australian workforce using a computer assisted telephone interview (CATI) methodology. The survey was part of the National Hazard Exposure Worker Surveillance (NHEWS) project aimed at gathering information to guide future programmes in the prevention and reduction of the most prevalent occupational diseases. Noise was considered a significant occupational disease in Australia and the survey estimated that around 30% of workforce participants were exposed to noise above 85 dB. This translated to around 3.3 million individuals in 2010 terms.

METHODOLOGY

General

Determining the distribution of the workforce across all Australian industries is a reasonable task using the defined procedures facilitated in the *Australian – New Zealand Standard Industry Classification* code (ANZSIC: 2006). The code analyses major industry divisions, systematically breaking them into smaller units ultimately reaching specific areas equivalent to individual workplaces. By assessing noise exposure in workplaces and applying the data to the number employed, a profile of noise exposure across Australian is estimable.

The ANZSIC breaks industry into: *Division*; *Sub-division*; *Group*; and *Class Codes and Titles*. The ANZSIC can be used in conjunction with figures produced monthly by the Australian Bureau of Statistics (ABS) on employment, the *ABS - Australian Labour Market Statistics* as they match with respect to classifications. The ANZSIC has 19 *Divisions*; 86 *Sub-divisions*; 212 *Groups*; and 505 *Class Codes and Titles*.

Given assured availability of the numbers for people in the workforce we now need to consider a convenient way to estimate the distribution of noise exposure within each industry. To do this means carrying out noise exposure measurements and assessments at the most basic level of ANZSIC, the *Class Code and Title*, in actual workplaces. This can be carried out using large scale dosimetry, noise exposure surveys and/or noise exposure averaging across workplaces. These measures were in fact carried out for this project using dosimetry and task sampling procedures in accordance with the requirements of AS/NZS 1269.1 (2005) *Occupational noise management, Part 1: Measurement and assessment of noise imission and exposure*. Clearly to make some sort of initial estimate the number of workers exposed to hazardous noise for the nation's workforce broad generalisations will have to be assumed.

An example of the process

As a simple example consider a large, meat processing facility employing around 400 people that was actually measured during the project. Using the ANZSIC the *Division* code is 'C'; *Subdivision* '11' *Food Product Manufacturing* ; *Group* '111' Meat and Meat Product Manufacturing; and *Class Code and Title* '1111' '*Meat Processing*'. The complete code for the location is C1111. In total for the *Manufacturing* division there are 15 *Subdivisions*, 55 *Groups* and 142 *Class Codes and Titles*. For a comprehensive sample, several of each of the 142 *Class Codes and Titles* should be visited. However this may not always be practical or necessary. The *ABS Australian Labour Market Statistics.6105.0.April 2010* (ABS: 2010) shows there were 193,900 employed persons in the Food Product manufacturing industry.

The average measured daily noise exposure ($L_{Aeq,8h}$) for workers sampled in this meat processing facility (n = 16) was 90.1 dB (SD = 4.0). The range of exposures was 85.8 dB to 100.4 dB and the 95% confidence interval (95%CI) was [82.3 to 97.9 dB]. At this particular meat processing facility there was one main work area due to the nature and layout of the processes. Some work sites may consist of many work areas each with numerous tasks. So the above estimates are to be taken as representative for this workplace. Noise exposure estimation at this level must ensure that the appropriate *ANZSIC Class Code and Titles* are addressed and that samples are representative

The next step in the process is at the *Group* level including all Manufacturing up to a C111*x* prefix. In this *Group* there are three *Class Code and Titles*, most average around four to five. Next is the *Subdivision* of *Food Product Manufacturing* commencing with prefix C11*xx* of which there are 15 in this particular case.

For this part of the exercise 45 organisations in the *Manufacturing* industry were visited including 246 separate workplaces where 672 activities were measured. These industries included: *Food; Bakery; Beverage & Tobacco; Textile, Leather, Clothing and Footwear; Wood Product; Non-metallic Mineral Products; Primary Metal & Metal Products; and Furniture & Other Manufacturing* (nine out of 15 Sub-divisions). The mean exposure for all of these industries was estimated to be 83.0 dB (SD = 7.2). If we assume our sampling was sufficient and the industries measured are representative of the *Food Manufacturing* industry as a whole, and that the noise exposure is distributed normally over those in the industry we can estimate, through z-scores, that approximately 161.6k individuals out of a total of 193.9k are exposed to levels above the recommended Standard of 85 dB. The more workplaces and the more individuals we can assess the better the accuracy (trueness and precision). This is a limitation of the current study.

The method can now be extend across all industries by building from *Class Code and Title* to *Group*, *Sub-division*, concluding with an estimate for all *Divisions* and all industry. This is carried out with *Table 1* providing a first order approximation of 2.2m (20%) out of an estimated 10.90m people in the workforce regularly exposed to noise levels above the recommended Exposure Standard ($L_{Aeq,8h}$) of 85 dB with a further 1.0m (9.4%) exposed to greater than 90 dB. A further 4.2 million (38.6%) of the workforce is exposed to levels above 80 dB.

DISCUSSION

The analysis of exposure as presented in *Table 1* shows that based on 2010 figures for *Employed Persons* (ABS: 2010) in Australia there were 10.9m people in the Australian workforce, of whom 4.2m (38%) were regularly exposed to levels above 80 dB and 2.2m (20%) were regularly exposed to noise levels at or above the Exposure Standard of 85 dB. Of those above the Exposure Standard around 1.0m (9.4%) are at or above 90 dB. At this point it should be noted that due to the non-linear characteristics of using decibels as a measure, an exposure of 80 dB represents approximately one third (32%) of the Exposure Standard of 85 dB (100%) while an exposure of 90 dB represents 3.2 times, or 320%, of the recommended Exposure Standard.

At this stage it should also be noted that in accordance with the requirements of noise immission measurements (NOHSC: 1998) no consideration has been given to any attenuation provided through the use of hearing protectors whereby users are considered to be in a state of 'protected exposure' (Williams: 2011). As defined by AS/NZS 1269.1 (2005) "*[e]xposure to noise is determined at the person's ear position without taking into account any protection that may be offered by personal hearing protectors"* (p 6).

Comparison with similar studies

A much quoted Australian work by Waugh (1986) estimated that although there was *"no accurate epidemiological data … it has been estimated* [1985] *that between a quarter and a half million people work in hazardous noise environments in Australia"* (p 1). At the time the upper estimate represented around 12.2% of the Australia workforce (NOHSC: 2004).

The Australian Safety and Compensation Council (ASCC: 2006) reported a Swedish study carried out by the National Institute for Working Life (2002 [undiscoverable in 2013]) that estimated *"more than 800,000 out of the 3.9m employees in Sweden are exposed to noise so loud that they can't communicate in a normal voice during at least ¼ of their working hours"* (p 23). This figure represents about 20.5% of the Swedish workforce. In the UK estimates are that around 2m people are regularly exposed to loud noise at work, with about 1.1m to levels above 85 dB (EU: 2005). With the UK workforce at 25.6m (UK National Statistics: 2001) this is an exposure rate of around 4.3%.

In the USA an estimate that 9.4 million workers from the manufacturing sector were exposed to hazardous noise levels at or above 80 dB on a daily basis, was published by the Centres for Disease Control (CDC) in 1986 (CDC: 1986). This estimate used data gathered by the National Occupational Exposure Survey conducted by the National Institute for Occupational Safety and Health (NIOSH) between 1981 and 1983 (discussed in NIOSH: 1998) and followed similar estimates by the US Environmental Protection Agency (EPA: 1981). The EPA *"estimated that more than 9 million US workers were occupationally exposed to daily noise levels above 85 dB(A)"* (NIOSH: 1998, p 12).

In the same report NIOSH (1998) attempted a fractional allocation of the distribution of the number workers exposed to noise in seven major economic sectors (professional; administrative; clerical; sales; services; agricultural; and production) and nine occupational categories (agriculture; mining; manufacturing; electricity; construction; trade; transportation; finance; and services). The apportion of noise exposure to the seven occupational categories was further developed across an expanded nine economic subsectors by the WHO (2004) to produce a *"proportion of workers in each occupational category and economic subsector exposed to noise levels > 85 dB(A)"* (p 12) using the above NIOSH work *"either by extrapolation from the most relevant subsector of the survey of production workers .. or by expert judgement"* (p 13). This methodology was subsequently extended to estimate the importance of noise as a risk factor for hearing loss on a global scale (Nelson et al: 2005). These estimates ranged from 7% to 21% (averaging 16%) depending on world region and gender.

The American Academy of Audiology (AAA: 2003) in a position statement on *"Preventing Noise-Induced Hearing Loss"* suggested that the then current figures were *"upwards of 5 million, perhaps as many as 30 million Americans occupationally exposed to noise levels greater than 85 dBA"*. This represents a workforce population exposure range from 3.6% to 21.7% given that the US workforce at the time was at 138 million (US Department of Labor: 2004).

Important to note is that in midst of the works quoted above a WHO report into the *'Prevention of Noise-Induced Hearing Loss'*, under the heading *'Epidemiology of noise-induced hearing loss'*, included a statement that:

"A literature search for 1990 – 1997 produced no published work that would enable accurate comparisons to be made amongst and within countries concerning the epidemiology of hearing impairment and the contribution of environmental noise (including occupational and social sources eg aircraft, traffic, music, etc)." (p 12, WHO: 1997)

The most recent relevant Australian work available as mentioned previously, is from the CATI survey of 4,500 respondents conducted by Safe Work Australia (2010) across all Australian industries estimating that,

"Between 28% and 32% of the Australian workforce are likely to work in an environment where they are exposed to non-trivial [≥ 85 dB(A)] loud noise generated during the course of their work." (p 1)

This estimate is greater than the current estimate of 20% which can be considered as a reasonable starting point for future refinement.

Implications

The most obvious implication of these figures is the potential for noise injury to hearing and the subsequent hearing loss. Combined Australian/New Zealand Standard *AS/NZS 1269.4 Occupational noise management, Part 4: Audiometric assessment* (AS/NZS 1269.4: 2005) uses the methodology of *ISO 1999: 1990 Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment* and *NAL Report 118, Improved Procedure for Determining Percentage Loss of Hearing* (NAL: 1988) to calculate the expected percentage loss of hearing (PLH) of a noise exposed group of individuals for a given time. If we consider an unscreened male population exposed to an equivalent continuous, A-weighted exposure level ($L_{Aeq,8h}$) of 80 dB then at the end of thirty years, for example, 61% of those exposed could expect to have a mean PLH of 6%. With an exposure of 85 dB this rises to 70% of the exposed population expecting a mean PLH of 7% and at 90 dB, expect 82% with a mean PLH of 8%. For females the respective values are: at 80 dB, 24% with a mean PLH of 4%; at 85 dB, 34% with a mean PLH of 4%; and at 90 dB, 53% with a mean PLH of 5%.

These PLH figures represent a significant impairment to the individual dependent on their particular circumstances. The figures are even more important when it is considered that *"exposure to excessive noise is the major avoidable cause of permanent hearing impairment worldwide"* (WHO: 1997).

More recent evidence has been provided that prior to audiometric indication of hearing loss there may be significant difficulty experience in temporal and speech processing ability (Brattico et al: 2004; Kujawa & Liberman: 2009; Kujala & Brattico: 2009; Feng et al: 2010; Kumar et al: 2012). If true, this would explain the reports of difficulty in holding conversations in the presence of background noise from those regularly exposed to noise at work.

Methodological limitations

Besides the limited number of work places that are able to be visited, as mentioned above, the main limitation of this methodology is that there may be an inherent over-estimation of the number of people in the respective industries who are not exposed to hazardous noise. Due to the nature of workplace noise assessment, noise measurements are taken in noisy areas and of noisy tasks but few if any are recorded of the quieter areas. While supervisors may frequently venture high noise areas, office workers, middle and senior management would only rarely be in such a position. This combination may lead to an over-estimation of the exposed population. This difficulty could be addressed by using calculated percentile values of the exposure distribution rather than an assumption of normality.

Consequently while the exposure measurements and calculations themselves may be satisfactory there is an underlying uncertainty as to how these measures are representative of the particular industry Division, Subdivision, etc, as a whole or even on average. Over time as more measurements are carried out the more the uncertainty can be reduced. Given the magnitude of the problem this will be a long, slow process.

This work did not directly consider the effects of impulse noise except where these are integrated into any continuous noise exposure estimates.

Given the consideration of these limitations their influence indicates a trend toward over-estimation the incidence of regular noise exposure. The current value is an under- estimate when compared to the survey by Safe Work Australia (2010).

CONCLUSION

The methodology used in this study indicates that for the Australian workforce around 20% of employed persons are exposed to levels equal to or greater than 80 dB and 9.4% exposed to equal to or greater than 90 dB. The proposed model is of the appropriate order of magnitude of estimates from comparable studies and, with more refinement, is capable of greater accuracy.

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Table 1: The fraction and total numbers of noise exposed workers in the Australian workforce for 2010 based on the number of employed person estimates (ABS: 2010) with respect to ANZSIC primary code and division (ANZSIC: 2006).

						Employed	At risk		Low risk		Above Standard		Moderate risk		High risk	
ANZSIC				Mean, LAeq		persons	>80 dB	N>80 dB	80 dB to 85 dB	80 dB<N<85 dB	>85 dB	N>85 dB	85 dB to 90 dB	85 dB<N<90 dB	>90 dB	N>90 dB
Code	Industry	No. Sites	No. Activities	*(dB)*	*SD*	*('000)*	*Fraction*	*('000)*	*Fraction*	*('000)*	*Fraction*	*('000)*	*Fraction*	*('000)*	*Fraction*	*('000)*
A	*Agriculture, Forestry & Fishing*	110	308	80.0	17.44	355.5	0.500	177.750	0.113	40.110	0.387	137.640	0.104	36.966	0.283	100.674
B	*Mining*	3	16	89.5	3.78	172.4	0.994	171.369	0.111	19.127	0.883	152.241	0.436	75.112	0.447	77.129
C	*Manufacturing*	245	656	82.8	7.30	997.4	0.649	647.660	0.268	267.086	0.382	380.574	0.220	219.003	0.162	161.571
D	*Electricity, Gas, Water & Waste Services*	4	28	79.1	13.18	126.7	0.473	59.901	0.146	18.444	0.327	41.457	0.123	15.595	0.204	25.861
E	*Construction*	63	192	83.9	8.54	979.6	0.676	662.256	0.227	222.655	0.449	439.601	0.211	206.921	0.238	232.680
F	*Wholesale Trade*	21	21	80.4	5.20	431.5	0.531	228.979	0.342	147.778	0.188	81.201	0.156	67.205	0.032	13.996
G	**Retail Trade*			75.0	5.00	1175.2	0.159	186.452	0.136	159.716	0.023	26.736	0.021	25.150	0.001	1.586
H	*Accommodation & Food Services*	62	215	78.5	6.40	741.7	0.407	302.129	0.252	187.237	0.155	114.892	0.119	88.059	0.036	26.833
I	*Transport, Postal & Warehousing*	21	81	81.5	11.30	556.8	0.553	307.800	0.174	97.117	0.378	210.683	0.152	84.867	0.226	125.815
J	*Information, Media & Telecommunications*	7	12	79.0	12.50	208.3	0.468	97.509	0.153	31.767	0.316	65.742	0.126	26.284	0.189	39.458
K	**Financial & Insurance Services*			75.0	5.00	408.2	0.159	64.763	0.136	55.476	0.023	9.287	0.021	8.736	0.001	0.551
L	**Rental, Hiring, Real Estate Services*			75.0	5.00	171.8	0.159	27.257	0.136	23.348	0.023	3.908	0.021	3.677	0.001	0.232
M	**Professional, Scientific & Technical Services*			75.0	5.00	852.0	0.159	135.174	0.136	115.791	0.023	19.383	0.021	18.233	0.001	1.150
N	*Administration & Support Services*	6	10	74.5	14.09	387.0	0.348	134.730	0.120	46.466	0.228	88.264	0.092	35.767	0.136	52.497
O	*Public Administration & Safety*	1	21	81.8	7.99	672.4	0.589	396.124	0.245	164.554	0.344	231.570	0.192	129.111	0.152	102.460
P	**Education & Training*			75.0	5.00	829.8	0.159	131.652	0.136	112.774	0.023	18.878	0.021	17.758	0.001	1.120
Q	**Health Care & Social Assistance*			75.0	5.00	1193.9	0.159	189.419	0.136	162.257	0.023	27.161	0.021	25.550	0.001	1.612
R	*Arts & Recreation Services*	48	260	80.1	5.90	193.6	0.507	98.109	0.304	58.784	0.203	39.325	0.156	30.288	0.047	9.037
S	*Other Services*	15	36	78.3	9.36	449.3	0.428	192.273	0.191	85.765	0.237	106.508	0.131	59.040	0.106	47.468
	*Currently no data available			**Totals**		**10903.1**		**4211.306**		**2016.254**		**2195.052**		**1173.322**		**1021.730**
	Noise estimates are from experience			% =		100.0		38.6		18.5		20.1		10.8		9.4