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Occupational Noise exposure in Amplified Music Venues in Leinster; an Exploratory Risk Analysis.

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Occupational Noise Exposure in Amplified Music Venues in Leinster: An Exploratory Risk Analysis

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ABSTRACT

Occupational noise exposure in amplified music venues in Leinster: an exploratory risk analysis

Due to transposition of the EU Directive 2003/10/EC into Irish Law, the entertainment sector was obligated to comply with the requirements of the Safety, Health and Welfare at Work (General Application) Regulations 2007, Chapter 1 Part 5: Control of Noise at Work since February 2008. Despite this, there is a lack of baseline data on the adoption and appreciation of these regulations within the sector. The aim of this study was to conduct an exploratory risk analysis of occupational noise exposure in nightclubs and examine the application of occupational noise legislation in this industry.

Noise risk assessments were conducted in twenty Leinster nightclub/discobars to establish employee noise exposure and their risk of noise-induced hearing impairment. Compliance with the requirements of the Noise Regulations, 2007 and the opinions of the enforcement officers was also examined. Octave band analysis was conducted to select suitable hearing protection for employees. Finally, attitudes towards the use of control measures such as hearing protection, were explored through focus groups and training interventions.

The average nightclub bartenders' daily noise exposure ($L_{EX, 8h}$) was 92 dBA, almost four times more than the accepted legal limit. None of the venues examined were fully compliant with the requirements of the 2007 Noise Regulations and awareness of this legislation was limited. Hearing protection was only worn by employees in one venue. The training intervention led to a significant increase in employees' noise knowledge, but without managements encouragement hearing protection use did not significantly increase ($p > 0.05$).

DECLARATION

I certify that this thesis which I now submit for examination for the award of PhD, is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate study by research of the Dublin Institute of Technology (DIT) and has not been submitted in whole or in part for another award in any other third level institution.

The work reported on in this thesis conforms to the principles and requirements of the DIT's guidelines for ethics in research.

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Signature ________________________________ Date ______________

Candidate

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BS	British Standard
CEHOG	Chief Environmental Health Officers Group
CEO	Chief Executive Officer
COP	Code of Practice
CPD	Continuous Professional Development
DIT	Dublin Institute of Technology
DJ	Disc Jockey
EASHW	European Agency for Safety and Health at Work
EHO	Environmental Health Officer
EU	European Union
FAS	Foras Aiseanna Saothair
HBM	Health Belief Model
HPD	Hearing Protection Devices
HPM	Health Promotion Model
HSA	Health and Safety Authority
HSE UK	Health and Safety Executive in the United Kingdom
HTLA	Hearing Threshold Level associated with Age
HTLAN	Hearing Threshold Level associated with Age and Noise
IHC	Inner Hair Cell
INIA	Irish Nightclub Industry Association
IRCSET	Irish Research Council
ISO	International Organisation for Standardisation
LAs	Local Authorities
NI	Northern Ireland
NIH	National Institute of Health
NIHL	Noise Induced Hearing Loss
NIOSH	National Institute for Occupational Safety and Health
NIPTS	Noise Induced Permanent Threshold Shift
OAE	Otoacoustic Emission
OBA	Octave Band Analysis
OHC	Outer Hair Cell
OHSAS	Occupational Health and Safety Assessment Series

PPE	Personal Protective Equipment
PTA	Pure-Tone Audiometry
PTS	Permanent Threshold Shift
SD	Standard Deviation
SEO	Special Exemption Order
SLM	Sound Level Meter
SPA	Safe Pass Alliance
SPSS	Statistical Package for the Social Sciences
TTS	Temporary Threshold Shift
WHO	World Health Organisation

GLOSSARY OF TERMS

A-Weighting (dB A)

The filtering of sound that replicates the human hearing frequency response.

Decibel (dB)

Unit used to report sound intensity. Due to its logarithmic scale, a 3 decibel increase in sound level represents a doubling of sound intensity.

Exposure action value

The daily noise exposure level or peak sound pressure level which, if exceeded for any employee, requires specified action to be taken to reduce risk.

Exposure limit value

The level of daily noise exposure or peak sound pressure which must not be exceeded for any employee.

Frequency

Number of oscillations per unit time. Expressed in Hertz (Hz) where one Hertz is equal to one cycle per second.

$L_{A,eq}$

A-weighted time-averaged sound pressure level.

$L_{EX,8h}$

An employees calculated daily noise exposure, generally over an 8 hour period.

$\overline{L}_{EX,8h}$

An employees calculated weekly noise exposure, averaged over a number of days.

L_{Cpeak}

The maximum value of the “C”-frequency weighted instantaneous noise pressure.

Octave Band

Groups of frequencies defined by standards where the upper frequency of each band is equal to twice the lower frequency of the next higher band *e.g.* 250, 500, 1,000 Hz.

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GUIDE TO THE THESIS

Introduction

New noise legislation was introduced to Ireland in 2006 and has been applicable to the entertainment industry since 2008. Previous studies of nightclub noise levels used methodologies which focused on noise levels and exposure, or on noise levels and hearing threshold shifts but few studies have comprehensively integrated noise level studies with an exploration of compliance issues.

Layout of the thesis

This thesis is organised into 8 chapters, based on the 3 aspects of risk analysis *i.e.* noise risk assessment, noise risk management and noise risk communication, that guided the study.

Chapter 1: A detailed literature review which covers noise and its measurement, relevant health and safety legislation, the entertainment industry in Ireland and the influence of safety culture on employees attitudes and behaviours.

Chapters 2, 3 and 4: These methodology chapters are separated into the 3 aspects of noise risk analysis: Noise Risk Assessment, Noise Risk Management and Noise Risk Communication. Figure A shows the application of these methodologies in the stages of risk analysis. Figure B summarises the sub-studies of the research *e.g.* interviews, surveys, noise measurements, focus groups and training interventions.

Chapter 2 covers the noise risk assessment methodologies which were used to establish whether there was a risk to employees health from noise exposure. Noise monitoring was conducted in 20 amplified music venues.

Chapter 3 focuses on the noise risk management in the venues. This was addressed by exploring areas where improvements could be made to reduce noise related risks *i.e.* compliance with Noise Regulations, 2007, adherence to the guidance document "Noise of Music" and enforcement officers views of compliance. It also explored the selection of suitable hearing protection as a noise control for the industry.

Chapter 4 examined noise risk communication. This involved garnering employees' opinions about noise in their workplace and about barriers faced by managers when seeking to comply with the revised Noise Regulations. Focus group findings fed directly into the development of a training intervention designed to raise awareness of effects of noise on health and to promote the wearing of hearing protection.

Chapters 5, 6 and 7: These 3 results chapters present the key findings of the research, split into the 3 components of risk analysis. The analysis of the results divided amplified music venues *i.e.* nightclubs and disco-bars, into 2 distinct categories since nightclubs were significantly louder than disco-bars.

Chapter 8: Finally, the discussion and recommendations chapter addresses the employees noise exposure, considers the venues compliance with the revised Noise Regulations, 2007 and points out the difficulties faced by management in becoming compliant with the Noise Regulations, 2007. A series of recommendations arising from this research are presented along with suggestions for further studies.

Figure A: Summary of methodologies utilised within 20 amplified music venues

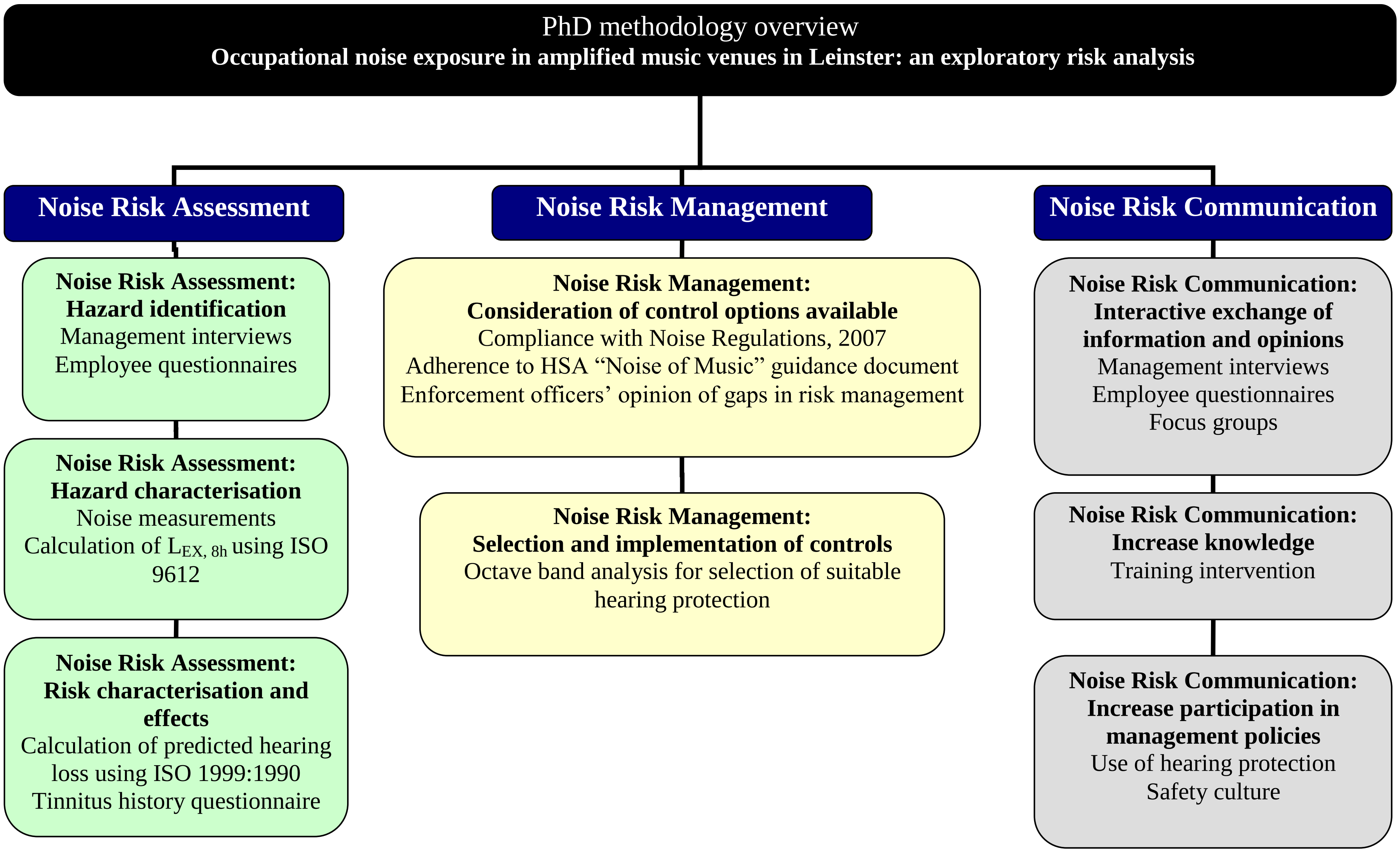
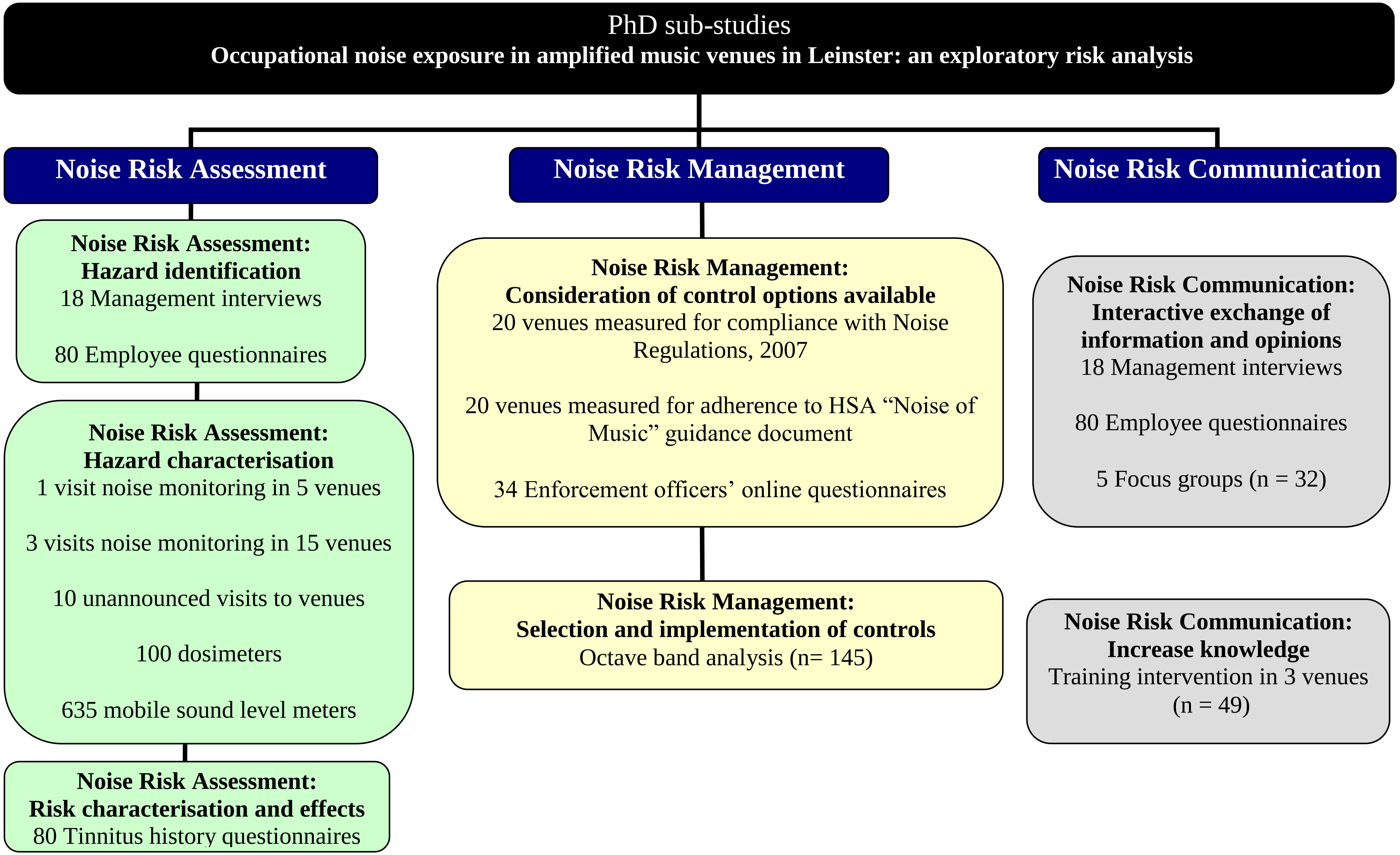


Figure B: Summary of sub-studies used within 20 amplified music venues



Chapter 1

LITERATURE REVIEW

1.0 Introduction

Exposure to sound levels at or above 85 dBA for 8 hours a day over several years will produce Noise Induced Hearing Loss (NIHL) (National Institute on Deafness and Other Communication Disorders, 2008). NIHL is irreversible but 100% preventable (European Agency for Safety and Health at Work (EASHW), 2005). In Europe NIHL is the most commonly reported occupational disease (EASHW, 2002) and in the United States (US) it is the second most commonly reported (National Institute for Occupational Safety and Health (NIOSH), 1999). In response to research on the continued prevalence of NIHL, the European Union (EU) introduced Directive 2003/10/EC, which revised the minimum occupational noise requirements to reduce the risk of employees developing NIHL.

1.1 Physics of sound

Sound is caused by pressure variations that are produced by a source of vibration (Berglund and Lindvall, 1995). Sound power (Watts (W)) is the total sound energy emitted from a source per unit time (Berglund and Lindvall, 1995). Sound intensity is defined as the sound power per unit area. Sound pressure (measured in pascals (Pa)) is defined as the force (in Newtons) of sound on a surface area (in m^2) perpendicular to the direction of the sound (United States Government, 1972). Due to the large pressure variations the human ear can detect (2×10^{-5} Pa to 200 Pa) and because the human ears response is not directly proportional to pressure, a logarithmic scale is used *i.e.* decibels (dB). The sound pressure level (L_p), in dB, is used to describe the ratio between two sound sources, defined in International Organisation for Standardisation (ISO) 1999:1990 by the following equation where p is the sound pressure (Pa) and p_0 is the reference sound pressure (20 μPa).

$$\text{Sound pressure level } (L_p) = 10 \text{ Log } (p/p_0)^2$$

Due to the logarithmic scale, an increase of 3 dBA represents a two-fold increase in sound pressure level. Thus, the difference, in decibels, between the 2 sounds, of power P_1 and P_2, is defined to be

$$10 \times \text{Log}\ (P_2/P_1)\ \text{dB}.$$

If the second sound, P_2, produces twice as much power as P_1, the difference in dB is

$$10\ \text{Log}\ (P_2/P_1) = 10\text{x}\ \log 2 = 3\ \text{dB}.$$

The frequency of sound is based on the number of vibrations per second, measured in Hertz (Hz) (Kiely, 1998). Humans are unable to hear the very low frequencies (infrasound) *e.g.* when whales communicate or high frequencies (ultrasound) *e.g.* transmitted when bats communicate. Sounds are generally audible to the human ear only if the number of vibrations per second is between 20 and 20,000 Hertz (Hz).

1.1.1 Classification of sound

According to Kiely (1998), there are 3 classifications of sound. These are;

1. **Continuous:** where sounds are uninterrupted and vary by less than 5 dB during the observation period.
2. **Intermittent:** a continuous sound that lasts for more than a second but is then interrupted for more than a second.
3. **Impulsive:** sounds which are short in duration *i.e.* they last less than a second.

1.2 Psycho-acoustics of sound and noise

Acoustically both sound and noise involve atmospheric pressure variations. Differences between them are subjective. Noise is defined as unwanted or damaging sound, *i.e.* a sound which has an adverse effect on health. The loudness of a sound is subjective and is influenced by a variety of factors: the frequency of the sound vibration, sound pressure level, and the response from the human ear and brain (Smith, Peters and Owen, 1996).

1.2.1 Response of the human ear to sound

The threshold of hearing is defined as the weakest sound that the average human ear can detect (McMullan, 2007). Fletcher-Munson equal loudness contours were generated in 1933 by asking people to judge when pure-tones of 2 different frequencies were perceived to be of equal loudness. The contours describe the average human ears subjective response to sound pressure level (in dB) at different frequencies (Hz). The ear is a non-linear device with maximum sensitivity at 3-4 kHz (ISO, 2003).

The ear can tolerate higher loudness levels at lower frequencies and as loudness increases the degree of non-linearity decreases. Once the sound pressure levels are greater than 40 dB in the mid-frequency ranges (250Hz - 4000 Hz), the subjective perception of noise levels changes. For example a reduction of 3 dB, which is a 50% reduction in sound intensity, will be barely noticeable to the normal ear. A ten-fold increase in sound intensity (10 dB) will only sound twice as loud to the human ear.

1.2.2 Octave bands

Pure-tones do not commonly exist outside of control laboratory conditions, for this reason octave band analysis is conducted. An octave is the interval between two points on a sound wavelength such that the frequency at the second point is twice the frequency of the first, for example 125 Hz and 250 Hz (McMullan, 2007). Although it is possible to analyse a source on a frequency by frequency basis, this is both impractical and time-consuming. For this reason, a scale of octave bands was developed. Each band covers a specific range of frequencies and can be used to identify the frequency content of the sound. Octave bands are a division of the frequency range into bands where the upper frequency limit of each band is twice the lower frequency limit (Butterfield, 2006).

When choosing hearing protection devices (HPD) it is essential to measure the sound levels in each of the frequency bands to which a subject is exposed. This is achieved by octave band analysis (OBA). Sadhra *et al.*, (2002) conducted OBA measurements in 3 university entertainment venues and identified that, especially after midnight, the lower frequencies (250 and 500 Hz) were most prominent. In the literature no other study of nightclub venue noise levels has reported the frequency characteristics of amplified music. The frequency bands of 63 Hz and 125 Hz have been identified as dominant in amplified music (Davies *et al.*, 2005).

1.2.3 Frequency weighting

Sound is measured in dB using a microphone, which generates a voltage proportional to the acoustic pressure acting on it. A sound level meter (SLM) is a portable, self-contained instrument which measures sound. When measuring sound it is essential to weight the sound pressure level in accordance with the frequency response characteristics of the human auditory system. The SLM will report the noise level based on what the human ear will hear. This is called frequency weighting and is the difference between the reading indicated on the SLM and corresponding sound level measured (International Electrotechnical Commission (IEC), 2002). Two internationally standardised weightings “A” and “C” are used to correlate to the frequency response of the human ear for different sound levels.

The A-weighting filter on a SLM is adjusted to the frequency sensitivity of the human ear. Any measurements that are “A-weighted” are denoted with an A, *e.g.* dBA.

C-weighting is commonly used for weighting higher sound pressure levels, due to its flat frequency response and is denoted with a C *e.g.* L_{Cpeak}. Weightings for A and C involve the specific addition or subtraction of decibels at certain frequencies to reflect the response of the human ear to noise (IEC 61672-1:2002). The characteristics of the A and C-weightings are described in Table 1.1.

Table 1.1 A and C frequency weightings (based on IEC 61672-1:2002)

Hertz	63	125	250	500	1000	2000	4000	8000
A	-26.2	-16.1	-8.6	-3.2	0	+1.2	+1.0	-1.1
C	-0.8	-0.2	0	0	0	-0.2	-0.8	-3.0

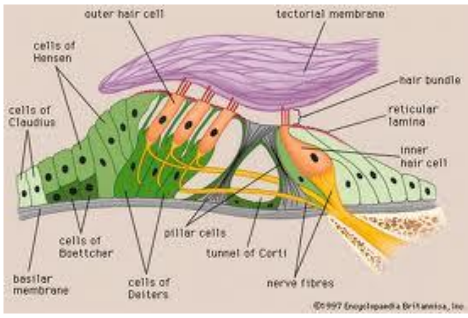
1.3 The anatomy of the ear and how humans hear

The ear enables us to hear very quiet sounds, like whispers and the rustling of the leaves, and to distinguish different voices in a crowded room. It allows us to know when the sound level has been too high and may have caused damage *e.g.* by ringing in the ears - often experienced after a rock concert (Heinrich and Feltens, 2006).

1.3.1 Anatomy of the ear

As illustrated in Figure 1.1, the ear consists of an air filled outer (pinna and ear canal) and middle ear (tympanic membrane, stapes, malleus and incus bones) and a fluid filled inner ear. Within the inner ear is the cochlea (hearing) and semicircular canals (balance). The cochlea contains cells, structures and fluids necessary for the detection of sound *e.g.* scala vestibule, scala media and scala tympani (Campbell and Reece, 2002).

Located in the air-filled middle ear are 3 bones; the malleus (hammer), incus (anvil) and stapes (stirrup) bones. These are collectively known as the ossicles, which transfer the vibrations of the eardrum to the inner ear (Campbell and Reece, 2002). The middle ear also has an aural reflex mechanism which reacts to loud sounds and tightens the eardrum, thereby lessening the force which is transmitted to the inner ear. In some cases, the defence mechanism may react too slowly to protect against sudden loud sounds *e.g.* impulsive loud music (Tumarkin, 1945).



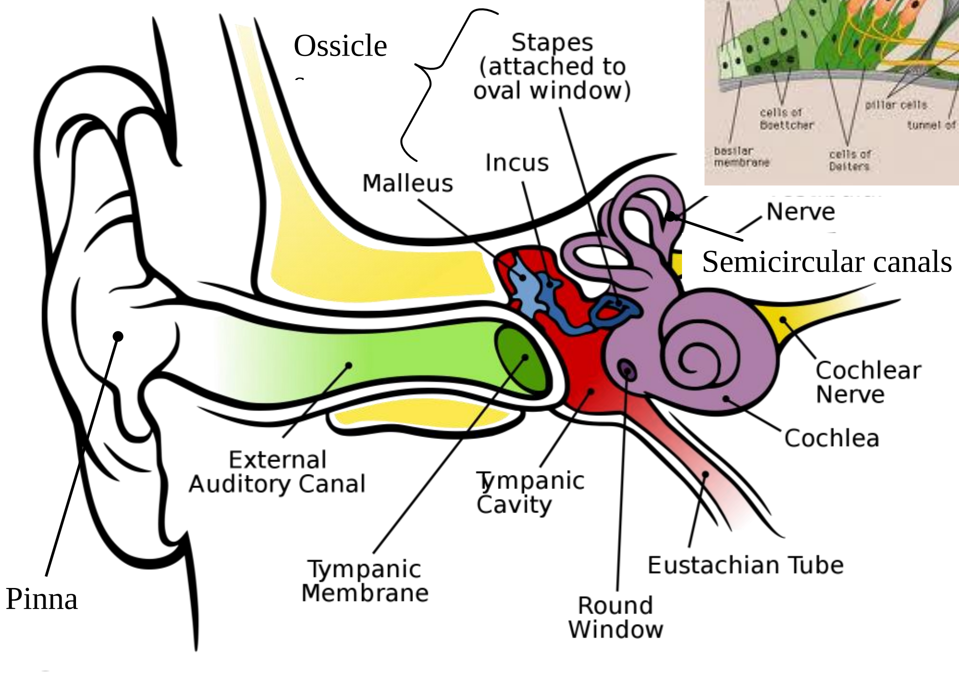


Figure 1.1 Anatomy of the ear

The inset shows the internal structure of the cochlea. (Reproduced from Sataloff and Sataloff, 2006)

1.3.2 How humans hear

The ear converts physical vibrations into nervous impulses (Berglund and Lindvall, 1995). To achieve sound conduction, the pinna collects the sound pressure waves and directs the waves down a 4 cm external auditory canal, towards the tympanic membrane (eardrum), which forms the boundary separating the outer and middle ear. Sound waves are transmitted by the vibration of the tympanic membrane, to each of the ossicles (mallus, incus and stapes). Amplification of a sound wave occurs when the stapes passes the vibrations into the first compartment of the fluid-filled cochlea through the oval window (Peake and Rosowski, 1997). This displacement of fluid results in a deformation of the basilar membrane, upon which the cells of the Organ of Corti lie, inside the cochlea. Hair cells, located in the Organ of Corti, move as a result of the displacement of fluid, converting the vibrations into a nervous impulse. This movement causes the stimulation of the auditory nerve, which sends a neural signal to the brain (Campbell and Reece, 2002).

1.3.2.1 Hair cells

There are 2 types of hair cells located in the Organ of Corti, the inner hair cell (IHC) and the outer hair cell (OHC). Hair cells contain clusters of hair-like structures called sterocilia on their upper surface. These sterocilia are rigid and may break if pushed beyond a stress point (Campbell and Reece, 2002). Unlike other tissues in the body, if the damage (breakage) is severe enough the hair cells do not regenerate.

The 10,000 IHC are thought to function primarily in sound transduction as they directly connect to individual nerve fibres of the auditory nerve. The 20,000 OHC operate as narrow-band amplifiers, with each cell amplifying a specific frequency (Shim, 2006). Due to the manner in which the OHC and IHC are linked, sound is increased in volume as it is received by the IHC (Fettiplace and Fuchs, 1999).

1.3.3 Different types of hearing loss

All of the cellular components of the Organ of Corti must function properly to achieve sound transduction, thus defects in any of the cells can result in deafness (Gillespie and Walker, 2001). While there are different types of hearing loss, presbyacusis is the process whereby people lose hair cells in the cochlea throughout their life and hearing gradually becomes less acute. Sensori-neural hearing loss is caused by noise damage and resides in the cochlea of the inner ear or in the nerve pathways to the brain (Kiernan, 2006).

1.4 How hearing is damaged by noise and diagnosed

Although exposure to moderate levels of noise is relatively harmless, exposure to loud noise over a prolonged period of time can impair hearing (Rabinowitz, 2000). Sound levels of less than 75 dBA are unlikely to cause permanent hearing loss (National Institute of Health (NIH), 1990). The risk of developing hearing loss depends on; sound intensity, exposure duration and genetic vulnerability of individuals (Sadhra *et al.*, 2002).

The ear canal is similar to a closed tube and resonates most efficiently at frequencies of 3-6 kHz and enhances sound pressure level in this range by up to 20 dB. This partly explains why noise at these frequencies damages our hearing most (Rabinowitz, 2000). When a person's hearing is damaged by noise, the OHC are not effectively working and consequently the amplification of sounds is reduced significantly. This leaves a person unable to hear softer sounds. It is accepted that the risk of permanent hearing loss after a short exposure to noise is low compared to the risk of permanent tinnitus due to this same exposure (Metternich and Brusis, 1999). It is generally accepted the risk of harm falls away below a daily noise exposure level of 85 dBA (Robinson, Lawton and Rice, 1994).

1.4.1 Temporary Threshold Shift (TTS)

Temporary Threshold Shift (TTS) is a temporary dullness in hearing following exposure to loud noises. The rate of TTS recovery varies from several minutes to several days (Clark, 1991). Repeated TTS over a few weeks to a few years may lead to accumulated cellular damage causing a Permanent Threshold Shift (PTS). There are two categories of permanent threshold shift – NIHL and tinnitus.

TTS cannot predict the extent of PTS but is a good early indicator of permanent damage (Luz *et al.*, 1973). Although short periods of exposure to amplified sound may be experienced without permanent hearing loss, the damage from chronic exposure to these sound levels is cumulative so that repeated slight hearing loss can eventually become substantial (Chung, 2005). Gunderson, Moline and Catalano (1997) observed that employees new to the industry perceived a TTS or ringing in the ears after work more often than the longer serving employees. They surmised that longer serving employees had become desensitised to perceptions of TTS or tinnitus after work. Sadhra *et al.* (2002) measured the hearing of 28 student employees' pre and post-shift to evaluate the effects of working in amplified music venues. TTS was associated with noise exposure and the greatest TTS was at observed at 4,000 Hz. Santos *et al.* (2007) reported that DJs experienced TTS following their sets.

1.4.2 Noise Induced Hearing Loss (NIHL)

Exposure to 90 dBA over 8 hours is accepted as a point at which more than a fifth of workers experience a form of hearing loss by the time they retire (Robinson, 1988). Estimates of the number of people affected worldwide by adult-onset hearing loss increased from 120 million in 1995 (World Health Organisation (WHO), 2001) to 250 million worldwide in 2004 (Smith, 2004). In Europe, 7% of employees reportedly suffer from work-related hearing difficulties (Eurostat, 2006). There are no specific Irish data on NIHL.

NIHL develops slowly as the result of exposure to continuous or intermittent loud noise and results from damage to the sensory hair cells located in the cochlea (Sataloff and Sataloff, 2006). NIHL is not, primarily, a loss of volume sensitivity but a loss of frequency specificity *i.e.* the ear is unable to focus (Niskar, 2001). Usually if a person acquires sensori-neural hearing loss it is most severe in the higher frequencies of 4,000-

6,000 Hz. NIHL is not only an occupational disease: Niskar (2001) estimated that 5.2 million US children have Noise-Induced Threshold Shifts.

1.4.3 Tinnitus

Tinnitus is a ringing or buzzing in the ears that is not caused by an external source. In most cases tinnitus disappears in a few days. When it persists tinnitus may become a problem. Tinnitus is a hearing dysfunction that is not yet fully understood, but is known to involve a physiological alteration of the inner ear (Puel, 2002; Kaltenbach, 2002). For many people, tinnitus is the first sign of hearing impairment. Regular exposure to 80 dBA is sufficient to cause tinnitus (Health and Safety Executive in the United Kingdom HSE UK, 2008).

It is widely accepted that hearing damaged by amplified music manifests itself in the form of tinnitus rather than a reduction in hearing (Axelsson and Prasher, 1999). Bray *et al.* (2004) reported 74% of the DJs who participated in their study on noise exposure and hearing loss experienced tinnitus and had a mean $L_{EX,\,8h}$ of 96.1 dBA. Tinnitus was reported more often by younger employees (<30 years) and those employees who were working less than 1 year in the industry (Lee, 1999).

1.4.4 Pure tone audiometry

Audiometric testing is the means by which hearing loss is diagnosed. Pure tone audiometry (PTA) is a subjective measurement of hearing loss as it relies on the patient’s response to a pure-tone stimulus (Forshaw, 2011). By introducing tones of different frequencies into the ear, it is possible to diagnose the severity of hearing loss as a result of the patient’s response to the tones. The diagnosis of hearing loss is based on the patient’s response to the lowest tones. Threshold shift is the precursor of NIHL (Smith, 2004). Hearing impairment is usually gradual because the OHC (amplifiers) are damaged first by excessive noise - the affected person often will not notice changes in hearing ability until a large threshold shift has occurred.

PTA is non-invasive and requires expensive equipment and expert testers. Current audiometric testing is not particularly sensitive for identifying NIHL due to intrinsic test-retest variability (Lutman, Davis and Ferguson, 2008). PTA has been identified as a poor indicator of slight cochlea damage, especially for younger people (Axelsson, 1994). Otoacoustic Emission (OAE) analysis is more reliable than PTA (Hall and Lutman, 1999). OAE is a release of acoustic energy into the ear canal, caused by the response of the OHC when stimulated (Lutman, Davis and Ferguson, 2008). The OAE sound can be measured with a small probe inserted into the ear canal. People with normal hearing produce emissions but those with hearing loss greater than 25-30 dB do not (Hall and Lutman, 1999). In 2011, the HSE UK held an OAE symposium to begin the initial review of OAE as a replacement for PTA (Forshaw, 2011).

1.5 Health and safety legislation in Ireland

Ireland is a member state in the European Union (EU) and consequently must transpose any EU directives into the Irish legislative system. Up to 1989 there was limited safety legislation in place. It was mainly directed towards specific industrial sectors e.g. mining or factories. The Barrington Commission report (1983) provided the impetus for the formation of the Health and Safety Authority (HSA) in 1989 (Ridley and Channing, 2008). This paved the way for the introduction of the Safety, Health and Welfare at Work Act, 1989 (Ridley and Channing, 2008) which was subsequently revised and updated in September 2005 (hereinafter, SHWW Act 2005).

1.5.1 Roles and responsibilities of the HSA

The responsibilities of the HSA include:

- Investigating serious accidents, ill-health and complaints.
- Taking enforcement action when an organisation is in breach of health and safety legislation.
- Providing information and advice to employers, employees and the self-employed on all aspects of workplace health and safety.
- Promoting education, training and research in the area of health and safety.
- Developing new laws and standards on health and safety at work. Designing and publishing a code of practice, guidance and information documents.

In 2011, the HSA completed 15,340 workplace inspections (HSA, 2012).

1.5.2 SHWW Act, 2005

The SHWW Act, 2005 was a comprehensive piece of legislation which detailed the principles of safety management. The revised SHWW Act, 2005 regards the safety statement as a fundamental component of the management of safety, health and welfare in the workplace. Its approach is based on the identification of hazards and the assessment of risks to health at the place of work. The SHWW Act, 2005 specifies the management's commitment to protecting employee's health and also outlines the employee's responsibilities for health and safety. The relevant changes between the SHWW 1989, Act and the SHWW Act, 2005 are indicted below;

- Mandatory safety statements for all organisations with more than 3 employees.
- Employers are responsible for carrying out health surveillance in work situations *e.g.* where employees hearing may be damaged.
- The employer was made fully responsible for the provision of personal protective equipment (PPE) for employees.

1.5.3 The General Application Regulations, 2007

Safety, Health and Welfare at Work (General Application) Regulations 2007, first introduced in 1993, are a framework for compliance and safety management which further the SHWW Act 2005. These General Application Regulations set out specific legal requirements in relation to certain health and safety issues such as manual handling, PPE and noise.

1.5.4 Safety, Health and Welfare at Work (General Application) Regulations 2007 Chapter 1 Part 5: Control of Noise at Work

EU Directive 2003/10/EC revised the minimum health and safety requirements to minimise the risk of hearing loss from the occupational exposure of employees to noise. In 2006, the Directive was adopted and transposed into Irish legislation through the Safety, Health and Welfare at Work (Control of Noise at Work) Regulations 2006. The 2006 Regulations were subsequently absorbed in November 2007 into the Safety, Health and Welfare at Work (General Application) Regulations 2007 under Chapter 1 Part 5: Control of Noise at Work (hereinafter, Noise Regulations, 2007). The European Communities (Protection of Workers) (Exposure to Noise) Regulations 1990 (hereinafter 1990 Regulations), were revoked and replaced. The Irish entertainment sector was permitted to continue to operate under the 1990 Regulations until 15th February 2008 when the stricter Noise Regulations, 2007 became effective.

1.6 Summary of the Noise Regulations, 2007

Compliance with the exposure criteria values does not guarantee that none of the employees will develop hearing loss. Rather they are regarded as values that represent a level of acceptable risk (Williams and Burgess, 2007). The following section outlines the requirements of the Noise Regulations, 2007 and explains the terms used therein *e.g.* daily noise exposure level, exposure limit value and exposure action values. Enforcement of the Noise Regulations, 2007 will then be considered.

1.6.1 Exposure limit value

An employee daily noise exposure level ($L_{EX,\ 8h}$) is a time-weighted average of noise exposure measured over an 8-hour day (ISO, 1990). The peak sound pressure (P_{peak}) is the maximum value of instantaneous noise pressure recorded, and it is C-weighted. The Noise Regulations, 2007 introduced a daily noise exposure limit value of $L_{EX,\ 8h}$ 87 dBA and a P_{peak} 140 dBC which must not be exceeded by an employee in any given day. Previously, the 1990 Regulations legislation did not stipulate an exposure limit value. The following noise exposures have the same associated health effects as the exposure limit value of 87 dBA *i.e.* if intensity of noise increases two-fold, the duration of exposure must decrease two-fold.

84 dBA for 16 hours = 87 dBA for 8 hours = 90 dBA for 4 hours

1.6.1.1 International Standard Organisation (ISO) 1999:1990

The 2003 EU noise Directive specifically refers to International Standard, ISO 1999:1990 for the formulae used to assess workers' exposure to noise. ISO 1999:1990 describes the methods to be used for calculating the time-weighted average for daily noise exposure levels ($L_{EX,\ 8h}$) and the weekly (5 days) noise exposure levels $\bar{L}_{EX,\ 8h}$). The Noise Regulations, 2007, allow an employer to estimate a noise exposure level $\bar{L}_{EX,\ 8h}$) over a week rather than the standard 8 hour day in circumstances where the noise exposure varies markedly from day to day *i.e.* by 5 dBA. For example if an employee works as a sound engineer at a concert for 2 days in the week and carries out office work on the other day their $\bar{L}_{EX,\ 8h}$ would be calculated over a week since a daily measurement may not be a true representation of their exposure.

Use of $\bar{L}_{EX,\ 8h}$ must not increase the level of risk to the employee's health. The Noise Regulations, 2007 also specify that the $\bar{L}_{EX,\ 8h}$ can only be used when the exposure limit value does not exceed 87 dBA and appropriate control measures are taken to reduce noise risks. The Noise Regulations, 2007, article 125(a), specifies that an employer must ensure, in so far as reasonably practicable, that the risk from exposure to noise is eliminated at source or reduced to a minimum. When calculating an employee's exposure limit value consideration may be given to the hearing protection (attenuation) benefits provided by suitable earplugs or earmuffs.

1.6.2 Exposure action values

Exposure action values refer to $L_{EX,\ 8h}$ and P_{peak} which, if exceeded, require the employer to take specific action to reduce the risk of hearing damage to the employee (Irish Government, 2007). As highlighted in Table 1.2 the revised exposure action values based on $L_{EX,\ 8h}$ have been reduced by 5 dBA in the Noise Regulations, 2007 compared to the 1990 Regulations. NIOSH have calculated that there is an 8% risk of developing NIHL over a 40-year lifetime exposure to 85 dBA compared to a 25% risk of developing NIHL at 90 dBA (NIOSH, 1998a). The P_{peak} limit values have also been revised in the Noise Regulations, 2007. Instead of measuring an un-weighted P_{peak} the revised regulations use a defined "C-weighted" P_{peak}. The C-weighted P_{peak} is considered a more accurate way of measuring instantaneous noise since it eliminates low frequency sounds and impulses (Smith, Peters and Owen, 1996).

Table 1.2: Changes to exposure action values

Measurement	Parameter	1990 Regulations	Noise Regulations, 2007
Upper exposure action value	$L_{EX,8h}$ P_{peak}	90 dBA 200 Pa	85 dBA 137 dBC @ 20 μPa
Lower exposure action value	$L_{EX,8h}$ P_{peak}	85 dBA 200 Pa	80 dBA 135 dBC @ 20 μPa

If $L_{EX,\ 8h}$ or P_{Peak} exceeds the exposure action values specific actions must be taken to reduce the NIHL risk, - no account can be taken of hearing protection. For example, employers must conduct a noise risk assessment when exposure levels reach 80 dBA. Hearing protection must be worn by the employees at 85 dBA, but only as a last resort if the noise at source cannot be eliminated or reduced to a safe level (HSA, 2007).

1.6.3 Other changes in the Noise Regulations, 2007

Under the 1990 Regulations employers were permitted to reduce noise to a level which was “to the lowest level reasonably practicable” (Irish Government, 1990). Under the Noise Regulations, 2007, employers must eliminate the noise at source or reduce it to a minimum noise level to ensure the employees will not exceed an 87 dBA exposure. Table 1.3 highlights the further differences between the Noise Regulations, 2007 and the 1990 Regulations.

Table 1.3: Noise Legislation: Changes from 1990 to 2007

Legislation	**2007**		**1990**	
Exposure action values	**80 dBA**	**85 dBA**	**85 dBA**	**90 dBA**
Assess and if necessary measure exposure	**X**		**X**	
Risk Assessment required	**X**		**X**	
Provide information and training	**X**		**X**	
Make hearing protection available	**X**		**X**	
Employees must wear hearing protection		**X**		**X**
Display mandatory signs warning employees of the noise levels		**X**		**X**
Ensure workstations are protected from unauthorised access by barriers		**X**		**X**
Provide hearing surveillance for exposed employees	**X**[a]	**X**[b]	**X**[b]	

[a] Preventative audiometric testing carried out by an occupational health professional

[b] Registered medical practitioner to carry out a hearing check.

Table 1.3 was reproduced from 1990 Regulations and Noise Regulations, 2007.

1.6.4 Noise legislation in other countries

Since Irish occupational noise legislation was transposed from an EU Directive on noise, the legislative requirements, *i.e.* exposure limit value and the lower/upper exposure action levels are the same as in all the EU member states. Worldwide there are very few differences in limit values since it is internationally recognised that excessive exposure to loud noise is harmful to hearing (NIH, 1990). The action level of 85 dBA is used in American, Canadian and Australian occupational noise legislation. However, they do not have lower and upper exposure action levels like the European legislation and no exposure limit value is specified. Some countries have specific occupational noise exposure limits set for employees in the entertainment industry, namely Australia, Switzerland, Italy and Finland (Santos *et al.,* 2007).

1.6.5 Enforcement of the Noise Regulations, 2007 in Ireland

The enforcing agency should be completely free of any connection to the industries being regulated, competent and sufficiently trained and committed to enforce the legislation effectively. Furthermore, penalties for breach of the legislation need to be tailored to avoid enforcement difficulties and must be serious enough to deter violations but not so excessive as to undermine public support (WHO, 2009).

Occupational noise enforcement in Ireland is carried out solely by the HSA. The HSA has a workforce of 197 which is comprised of inspectors, professional specialists, administrators and clerical staff. When the noise legislation was revised in 2006 the HSA carried out 39 inspections to monitor compliance. In 2008 the HSA inspectors carried out 411 noise inspections across all sectors which assessed how employers were addressing the reduced noise action levels. The HSA 2008 annual report concluded that 63% of workplaces had noise levels that exceeded 80 dBA and 50% exceeded 85 dBA.

1.6.6 Enforcement of noise legislation worldwide

The HSE UK and over 400 individual local authorities (LAs) are responsible for the enforcement of health and safety legislation in the UK, under the general direction of the Health and Safety Commission. LAs operate in partnership with the HSE UK to ensure that employers manage their workplaces with due regard to the health and safety of their workforce and those affected by their activities. To achieve this, local authorities, in cooperation with the HSE UK, conduct inspections and investigations, provide advice and take enforcement action where appropriate.

LAs are the principle enforcing authority in retailing, wholesale distribution, warehousing, hotel and catering premises, offices, and the consumer/leisure industries (HSE UK, 2000). The enforcing officers are qualified Environmental Health Officers (EHOs) who carry out food safety inspections on food premises in addition to health and safety legislation (Dunbabin, 1999). In US, Canada and Australia, health and safety enforcement in food businesses is also conducted by EHOs. In Ireland, the EHOs do not enforce health and safety in food businesses, apart from food safety.

The enforcing agency has an important role to play in ensuring compliance with the occupational noise legislation requirements. In Australia, a study carried out by Groothoff (1999) found that 29 out of 30 music venues exceeded 85 dBA. Only 2 operators had any significant knowledge of the requirements of the occupational noise regulations. Improvement notices were issued by the Health and Safety Inspectors outlining a range of options for the reduction of noise exposure. Two years later, 14 of the original venues were revisited. Although the noise levels remained in excess of 85 dBA, hearing protection was available in 12 venues and was actively imposed in 7 venues (Groothoff, 1999).

1.7 The nightclub industry in Ireland

In Irish law there is no definition of a nightclub. Irish nightclubs are considered, under the Intoxicating Liquor Act 1927 – 2008, to be a “licensed premises” that requires a separate “dance licence” to be issued under the Public Dance Hall Act 1935. To serve alcohol until 02:30 nightclubs must have a Special Exemption Order (SEO). This SEO must be obtained from the District Court each time the nightclub wants to open later than 00:30. The cost of each SEO is €410. Thus, a nightclub open 3 nights per week will pay €63,960 per annum to serve alcohol until 02:30 (Department of Justice, Equality and Law Reform, 2008). There is a 30 minute drinking up time from 02:30-03:00 where no entertainment can be provided. On Sunday nights the SEO only extends nightclub operating hours to 01:30, inclusive of the 30 minutes drinking up period. Prior to the 2008 amendment to the Intoxicating Liquor Act, nightclubs were permitted to serve alcohol until 03:30. The amendment also scrapped the “theatre licence” which allowed certain nightclubs to serve alcohol until 3:30am without any SEO (Irish Nightclub Industry Association (INIA), 2009).

1.7.1 Comparison of Irish nightclub industry with other countries

The Irish licensing system is different to the alcohol licences in the UK. The UK Licensing Act 2003 allows flexible opening hours for entertainment premises. This permits nightclubs to remain open for 24 hours, provided they present a satisfactory “operating schedule” to the local authority. The UK closing times are similar to the “24 hour” approach in other European countries. The “24 hour” approach to nightclub/disco operating times is widespread in Europe. Many European nightclubs close as late as 05:00-06:00, while the earliest opening time is 07:00. These early opening nightclubs are referred to as “afterhours” and usually close by mid-afternoon (Roberts, 2006; WHO, 2006).

1.7.2 Sale of Alcohol Bill

The Irish Liquor licensing is scheduled for revision with the draft of the Sale of Alcohol Bill. The Bill is hoped to consolidate and modernise alcohol licensing law to make it more understandable and user-friendly (Department of Justice, Equality and Law Reform, 2008). The Bill will not however, renege on the stricter drinking times amended by the Intoxicating Liquor Act 2008.

1.7.3 Representative nightclub body in Ireland

In Ireland the Irish Nightclub Industry Association (INIA) is an independent body which represents the interests of nightclubs. The INIA was initially set up in the mid-80s and at the time was referred to as the Discotheque Industry Association and later the Irish Discotheque Entertainment Industry Association. It finally became the INIA in the late 90s. The INIA is funded through membership subscriptions. Currently, the short-medium term objectives of the INIA are to lobby government to lower the SEO cost, introduce a nightclub permit and extend the operating hours of nightclubs in the forthcoming Sale of Alcohol Bill.

Currently, the INIA categorise a nightclub as a premises which only opens after 22:00, charges an admission fee, has a dedicated dance-floor area and uses SEOs to operate until 03:00 at the weekends. According to a report by Foley (2011) the nightclub industry has seen a substantial decline in business between 2007 and 2010. Based on 62 nightclubs surveyed by Foley (2011) the average number of nights for which nightclubs were open has dropped from an average of 4.2 nights per week in 2007 to 2.7 nights in 2010. Additionally, the INIA estimated that there are currently 328 nightclubs in Ireland compared to 430 in 2006 (Gurdgiev, 2009).

1.7.3.1 INIA lobby government

The INIA released a report in July 2009 on the social and economic effects of extending nightclub operating hours in Ireland. This is part of their campaign to extend Dublin nightclub operating hours to 04:00 in the city and to 02:30 outside Dublin, regardless of the night of the week. They wish to see the provision of entertainment reintroduced during the 30-minutes "drinking up" time (Gurdgiev, 2009). The report commissioned by the INIA highlighted the economic and social effects of the proposed reform but did not mention or assess the effect that the extended hours would have on the noise exposure of nightclub employees.

1.7.3.2 INIA Nightsafe Award

The INIA have developed "Nightsafe" which is a best practice award for the Irish nightclub industry. The INIA state the aim of Nightsafe is to:

"Improve the night time experience for nightclub customers and indeed all people out socialising late at night, local residents and business communities, and all other stakeholders in the day, evening and night time economies"

(INIA, 2011).

Nightclubs who successfully achieve the Nightsafe award are eligible for an insurance scheme specifically tailored for Nightsafe operators. The benefit of this insurance scheme is that the excess charged on claims is reduced. All nightclubs, regardless of whether they are members of the INIA or not can apply for the Nightsafe award. There are 4 headings nightclubs are audited under. These are:

- Prevention of crime and disorder.
- Public safety.
- Prevention of public nuisance.
- Protection of children from harm.

To achieve the Nightsafe award the nightclub must have achieved certain requirements before they are audited by the INIA and an independent insurance company representative. The criteria for noise control are based on the legislative requirements of the Noise Regulations, 2007 and the HSA guidance document “Noise of Music”.

1.8 Employee $L_{EX,8h}$ in nightclubs

Numerous documents refer to nightclub noise levels in excess of 100 dBA (HSA, 2009; HSE UK, 2008; Royal National Institute for Deaf people (RNID), 2004). According to the Noise Regulations, 2007, a person should not be exposed to this environment for more than 30 minutes per day (based on the 87 dBA exposure limit value of 8 hours). When assessing employee noise exposure in nightclubs, measuring the noise level on the dance-floor is inadequate (Smeatham, 2002). A HSE UK report carried out by Smeatham in 2002 outlined that other methods must be undertaken when measuring employee noise exposure in amplified music venues *i.e.*

- Use a personal dosimeter taking care to avoid mechanical shock to the microphone attached to the employee or
- Measure noise exposure using a fixed position microphone that is placed in a “representative” location.
- Record time spent at each work location including rest periods.
- Record the weekly work patterns for the employees and length of time the employees have been working in the nightclub industry.
- Gather information regarding other employments and other noise exposure.

Studies carried out in the UK, US and Australia have involved elements of the methods outlined in the HSE UK report. These studies identified amplified music venue employee $L_{EX,8h}$ to be between 72-98 dBA (Barlow and Castilla-Sanchez, 2012; Guo and Gunn, 2005; Bray *et al.*, 2004; Sadhra *et al.*, 2002; Dunbabin, 1999; Whitfield, 1998). The results were based on measuring noise levels through the use of a SLM or dosimeters worn by employees working in the venues. The largest number of premises assessed was by Whitfield, who carried out research in 1995 and 1998 in 19 venues. Whitfield estimated the $L_{EX,8h}$ for 20 bartenders from dosimeter results and working hours data based on employee interviews. Whitfield also carried out SLM analysis in the nightclubs to assess typical noise levels for the nightclub. The SLM analysis showed that noise levels rose within a nightclub as the evening progressed. This effect is known as the "cocktail" effect and was highlighted by Bickerdike and Gregory in 1980. The cocktail effect may cause the noise level to rise by 5 dBA.

Recently, Barlow and Castilla-Sanchez (2012) identified the level of compliance in 4 live/amplified music venues had to the UK occupational noise regulations. Additionally they estimated 62% (19/30) of employees exceeded the exposure limit value of 87 dBA and summarised that the industry was failing to meet regulatory requirements. Previously in Australia, a study was conducted by the enforcement agency Worksafe, in 17 music entertainment venues measuring employee $L_{EX,8h.}$ (Guo and Gunn, 2005). They highlighted that the bartenders and glass collectors in venues where live bands played were exposed to a mean $L_{EX,8h.}$ 4-5 dBA higher than employees where a DJ played pre-recorded amplified music.

Other studies by Bray *et al.* (2004) and Sadhra *et al.* (2002) recorded the noise levels in nightclubs and also carried out audiometric testing to measure the effects excessive occupational noise had on employees. Bray *et al.* reported nightclub the noise exposure levels of 23 Disc Jockeys (DJs) as 96 dBA and showed that 17% of DJs had early-onset

NIHL. Through pure-tone testing, Sadhra *et al.*, (2002) established that 29% (based on 21 employees) had a permanent threshold shift of 30 dBA across all frequencies.

1.8.1 Irish nightclub noise levels

In Ireland only one study has published data on noise levels in nightclubs (Mitchell, 2001). It was confined to counties Galway, Mayo and Roscommon in the West of Ireland and was carried out by Environmental Health Officers (EHOs). This study did not outline the number of venues sampled. The data measured patron exposure in various areas of the nightclubs using a dosimeter and found that 100% of nightclub dance-floors exceeded 90 dBA (Mitchell, 2001). The study focussed on patron noise exposure and hence compared the noise levels recorded to the WHO recommended patron noise limit of 100 dBA, for no more than an average of 4 hours, for no more than 5 times a year (Berglund and Lindvall, 1999). The WHO limit of 100 dBA was exceeded by 66% of nightclubs measured.

The recommended WHO limit was set because patrons were putting themselves at risk to hearing damage when socialising in late night music venues (Berglund and Lindvall, 1999). Nightclub employees would be expected to spend much longer in nightclub premises than patrons.

1.9 Safety management and safety statements

The SHWW Act, 2005 stipulates the minimum health and safety requirements with which an organisation must comply. Every employer with more than 3 employees must prepare a written safety statement that identifies hazards in the workplace (Irish Government, 2005). Specifically, a safety statement must detail how the health and safety of all employees will be protected and how the business will manage their health and safety responsibilities (HSA, 2006).

1.9.1 Risk assessment

A hazard is defined in Occupational Health and Safety Assessment Series (OHSAS) 18001:2007 as a

"source, situation, or act with a potential for harm in terms of human injury or ill health or a combination of these" (OHSAS 18001, 2007).

Section 19 of the Safety, Health and Welfare at Work Act, 2005 requires that employers identify hazards in the workplace under their control and assess the risks presented by these hazards (Irish Government, 2005). This requirement is designed to reinforce the notion that writing a safety statement is not enough; it must be regularly updated to reflect changing conditions in the organisation (Garavan, 2002). There is a distinct lack of noise risk assessments carried out in entertainment premises. This was highlighted by an extensive survey by Birmingham City Council where only 1 of 31 nightclub premises inspected had a satisfactory noise risk assessment (Morris, 2006).

1.9.2 Steps to take when carrying out a noise risk assessment

The techniques of noise risk assessment are facilitative tools, intended to identify all the risks associated with noise in the workplace (Cox and Tait, 1998). The Noise Regulations, 2007 outline a list of criteria detailing what should be contained in a satisfactory risk assessment, as shown in the following list:

1. Record the type, level and duration of exposure.
2. Indicate whether the exposure limit value/exposure action values are exceeded and account for any exposure in excess of the normalised 8 hour working shift.
3. Highlight the effects of noise exposure on vulnerable employees.
4. Consider any affects of sound vibrations, ototoxic substances and data from hearing tests.
5. Contain a review of suitable hearing protection and ensure the employees' ability to hear warning signals.

1.9.2.1 Workplace inspection

This is probably the best known and most widely used risk assessment technique. A noise specialist surveys the workplace. The on-site inspection allows face-to-face contact with employees who may have important information concerning sources of noise in the workplace. This risk assessment technique may be time consuming therefore preparatory work, such as creating checklists, is carried out before inspection takes place (Garavan, 2002).

1.9.2.2 Estimation of noise exposure

In 2009 there was a revision to the international standard ISO 9612:2009 "Acoustics – determination of occupational noise exposure – engineering method". This standard set out 3 strategies that may used to carry out adequate and reliable risk assessments. Few of the previous studies in the literature on noise measurements in nightclubs have referred to ISO 9612. This ISO 9612:2009 standard set out how to estimate the uncertainty associated with assessing daily noise exposure ($L_{EX,8h}$) of employees.

Microphones in fixed positions have been used successfully to measure average sound levels (L_{Aeq}) in situations were an employee works at a fixed workstation. Care must be taken to obtain accurate measurements of the time the employee spends at the workstation (Smeatham, 2002). Lutman, Davis and Ferguson (2008) reviewed the effectiveness of the occupational noise legislation in the UK (which is directly comparable to the Irish Noise Regulations, 2007). They recommended that noise surveys must be linked to the exposure patterns of individuals.

Dosimeters may be used to measure the total noise exposure of an employee over the measurement period ($L_{Aeq,T}$). The dosimeter microphone is placed on the employees shoulder in close proximity to the ear. A measurement correction is required due to the proximity of the microphone to the body. Note: mechanical shock to the microphone can influence measurements and it can be difficult to obtain reliable information from dosimeters in environments such as crowded pubs and clubs (Smeatham, 2002).

1.9.2.3 Application of suitable noise control measures

A hierarchy of control measures should be followed to ensure the best protection of the health and safety of employees. The control measure hierarchy is as follows;

- Elimination of noise sources.
- Control of noise at source.
- Collective control measures through work organisation and workplace layout.
- Personal protective equipment (EASHW, 2005).

1.9.2.4 Hearing health surveillance

Health surveillance is required under the Noise Regulations, 2007. The HSA describe hearing health surveillance as a regular and appropriate procedure to detect the early signs of hearing loss (HSA, 2007). The procedure for preventative audiometric testing involves a pure-tone audiometric test being carried out on both ears (HSA, 2007). Where the risk assessment indicates exposure above the upper Exposure Action Value of 85 dBA the employer must make the services of a registered medical practitioner available to carry out a hearing check. The difference between a hearing check and a preventative audiometric test is that the former involves a more thorough examination *i.e.* the employee is asked for their medical history, with particular reference to ear problems diagnosed in the past, followed by an examination of the external auditory canal and tympanic membrane. The audiometric test is then conducted in order to diagnose NIHL (HSA, 2007).

A previous study, by Savage (1999), indicated that in a sample of 800 civil construction workers exposed to noise in excess of 90 dBA the propensity to wear HPDs increased when workers became aware of their hearing loss. This is of major concern since NIHL is cumulative and by the time a person recognises that hearing loss has occurred it is irreversible (EASHW, 2005).

1.10 HSA guidance document "Noise of Music"

The HSA released an entertainment industry guidance document in February 2009 – "Noise of Music", detailing measures to protect employees hearing and obliging nightclubs to meet the stricter legal obligations of the Noise Regulations, 2007. The "Noise of Music" is a guidance document and its purpose is to clarify the provisions of the law and give general guidance. It is not intended as legal interpretation of legislation. A Code of Practice on the other hand provides practical guidance on the observance of health and safety legislative requirements. If an employer is the subject of criminal proceedings they can use their compliance with the Code of Practice in support of their claim to have been compliant with health and safety legislation (HSA, 2008). To date, there is no Code of Practice for noise management in nightclubs in Ireland.

The HSE UK has released a guidance document (Refer to Sound Advice, 2008), the content of which is similar to that of the HSA document. The HSE UK document however offers customised guidance for different types of entertainment industries *e.g.* orchestras, bars/nightclubs and recording studios (HSE UK, 2008). Australian authorities also have a Code of Practice called "Control of Noise in the Music Entertainment Industry". It was published in 1999 following consultation with entertainment industry representatives and the public. Despite the Code of Practice in Australia, Guo and Gunn (2005) concluded that further work was required to promote noise control measures.

The HSA guidance document "Noise of Music" highlights numerous noise control measures. Those relevant to the nightclub industry will be outlined below. The HSA advise the use of multiple control measures to control the risk of hearing loss to employees (HSA, 2009).

1.10.1 Eliminate the hazard

The first control measure is to avoid generating hazardous noise levels. Simply put, amplified music should be turned down. Recommendations by the HSE UK advise the noise level on the dance-floor should not exceed 103 dBA (HSE UK, 2008).

The HSA guidance document advises that reverberant spaces should be avoided although no precise indication of what is meant by this direction is given. Music premises reverberation time should be between 1-2 seconds (Smith, Peters and Owen, 1996). The use of soft furnishings in a nightclub venue can help to absorb some of the noise thereby reducing the noise experienced by people in the venue (Dunbabin, 1999).

1.10.2 Reduction of music volume

Studies have indicated that the minimum level that provides satisfactory patron entertainment is typically 94 to 96 dBA (Mawhinney and McCullagh, 1992; Dibble, 1988). The HSA "Noise of Music" guidance document did not specifically refer to nightclubs when they recommended that sound volume is reduced. They advised that smaller amplifiers may be used but noted that amplification and loudspeakers that operate without distortion are preferable to driving inferior systems at a higher output.

1.10.2.1 Sound limiters

A sound limiter is a device which is attached to the main power supply of an amplification unit in the nightclub. If the noise level exceeds a preset sound level a light flashes to warn the operator to turn the volume down. If the warning light is ignored the music will be automatically cut out (McMullan, 2007).

1.10.3 Physical separation of people from the noise

As sound waves spread out from a source they decrease in sound level. This is called attenuation. The total energy of the sound wave remains the same but the area into which the wave is moving is constantly increasing. The energy is therefore spread out over a larger area and sound pressure is decreasing (HSE UK, 2008). The HSA guidance document recommends that speakers be raised from the ground to increase attenuation from loudspeakers. No guidance distances are stipulated. Other research has suggested that a number of loudspeakers be used to ensure the sound level is uniformly distributed over the dance floor to prevent "hot spots" where excessively high levels may occur *e.g.* close to the loudspeakers (Whitfield, 1998).

"Where a venue has a number of loudspeaker positions around the building, consideration must be given to the direction and volume from each group of speakers. Those that are close to staff and other noise sensitive locations, such as the bar, should be individually controllable."(HSA" Noise of Music", 2009)

Hence, loudspeakers should be directional and located so that they concentrate their radiation onto the dance-floor and away from staff working locations. Checking with the manufacturer provides information on what is the best choice of orientation for a specific loudspeaker (HSE UK, 2008).

1.10.4 Rotation of employees

It is recommended that staff rotation be used to reduce the length of time an employee spends in a noisy location. This can only be achieved if the nightclubs have individual control over their loudspeakers and can create areas within the nightclub with lower noise levels (Smeatham, 2002).

1.10.5 Hearing protection

Making a wrong decision in the adoption of hearing protection could lead to employee hearing losses (Arezes, Bernardo and Mateus, 2012). If the nightclub management has any doubt that the noise level is in excess of 85 dBA they should assume that upper exposure action values control measures are required (HSA, 2009). The use of PPE is usually considered a last resort in noise control. It should be used only when all other methods of control have been explored (HSA, 2009). NIHL can be prevented by avoiding excessive exposure to noise and by using hearing protection (earplugs and earmuffs) (Rabinowitz and Duran, 2001). The HSA reported that > 80% of 472 companies examined, from a variety of sectors, used hearing protection (HSA, 2010).

In 2009, in a test case in the UK a factory employee was awarded £3,500 in compensation from her employer, Quantum Clothing Group, for her NIHL. The Court of Appeal ruled that the average employer should have been aware that workplace noise levels of 85 dBA were not safe and should have provided hearing protection to employees. The judge ruled that the provision of appropriate protection and instruction was neither expensive nor difficult and was such that a reasonable employer could use not use cost or difficulty as a valid reason for not having such a hearing protection policy (Baker Vs Quantum Clothing Group, 2009 UK). This judgement was overruled in 2011 by the Supreme Court who clarified that employers were not liable for employees deafness prior to stricter legislation being enacted, provided their $L_{EX,8h}$ was below 90 dBA (*i.e.* the previous legislative limit) (Supreme Court, 2011).

Figure 1.2 shows 3 different types of earplugs that are readily available in Ireland - disposable, reusable and flat response earplugs.

Max 1 Earplugs	Elvex Gelpods GC-20	Flat Response Earplugs
		

Figure 1.2: Selection of earplugs available in Ireland

Earplugs are a commonly used form of hearing protection. They are inserted and worn in the ear canal in order to prevent noise reaching the inner ear hair cells. Some earplugs are pre-shaped although many earplugs are made from compressible materials which the wearer forms before inserting them into the ear canal where they expand to form a seal (British Standard, 2004).

While it may be efficient to eliminate a noise at source or isolate the employees from the noise source (engineering controls) it is the proper use of the equipment or control measures which ultimately determines occupational safety (Cheung, 2004). The efficiency of HPD is not determined by their protective value measured in a laboratory. Rather it is dependent on how regularly they are used by employees (Paolucci *et al*, 2007). The removal of personal hearing protectors for even short periods of time can significantly reduce their effectiveness (Western Australia Commission, 2002). Wearing earplugs as a protective measure can be ineffective as a result of the behaviour of the wearer. A study by Toivonen *et al.* (2002) pointed out that people find it difficult to properly insert earplugs. Moreover, hearing protection may not be worn at all if it causes difficulties in hearing conversations and alarm sounds.

1.10.5.1 Selection of suitable PPE to protect from NIHL

Although engineering controls are high on the hierarchy of control measures such measures often may not sufficiently reduce noise levels. This is particularly true in a nightclub setting where patrons expect loud music (Reid, 2005). Therefore, hearing protection is a control measure which is easily made available to employees. Recommendations for the selection of suitable hearing protection have been outlined in a British Standard (458:2004) and are summarised in the HSA "Noise of Music" guidance document.

1.10.5.2 Hearing protection use and training

According to Clark and Bohne (1999)

> *"The most suitable hearing protection is the one that is actually used."*

Many workers fail to wear hearing protectors because they do not know how and when they should be worn (Stephenson, 2009). A study by Toivonen *et al.* (2002) concluded that people find it difficult to insert earplugs. Paakkonen *et al.* (2000) found that the attenuation (insertion loss) could be as high as 16–23 dB for earplugs. Training in the correct method of fitting earplugs is essential since this is a skill which employees must develop in order to ensure suitable attenuation from their hearing protection. Both Murphy *et al.* (2011) and Joseph *et al.* (2007) found that one-to-one or small-group training significantly improved the use of hearing protection.

1.11 Health and safety training

In order for a significant change to protect against occupational noise risks, training programmes must aim at affecting more than simply attitudes and perceptions. The training programmes must also ensure they allow for Contemplation, Preparation, Action and Maintenance, which is thought to cause effective changes (Prochaska *et al.* 1992).

In Ireland and Europe in the last ten years there has been an increased requirement for construction workers to undergo prescribed health and safety awareness and practical training. For example, to ensure that employees or contractors have completed this training, entry to construction sites has been restricted to those who can prove that they have undergone the necessary training. The proof of training has been in the form of a "safety passport" which contains the persons name and photograph and details of health and safety training which they have received (Sreenivasan, Benjamin and Price, 2003).

1.11.1 Construction health and safety training in Ireland

The Safe Pass programme has been rolled out in Ireland since the early part of the 21st century by Foras Áiseanna Saothair (FÁS) for those in the construction industry and local authority personnel. The training programme was developed in collaboration with industrial partners to enhance safety awareness in the construction industry. To receive a FÁS Safe Pass, participants must successfully complete a health and safety awareness training programme (Sreenivasan, Benjamin and Price, 2003).

1.11.2 Health and safety training in the United Kingdom

In the UK, they have implemented a Safe Pass Alliance that although originally designed for the engineering and construction industries has been extended, with sector specific training, for the petrol, mineral processing and food industries. The training is delivered on a single "core day" which focusses on 7 key health and safety areas. The employee's understanding is assessed by multiple choice questions and achievement is rewarded by the issue of a safety passport. The 7 key areas are:

- Introduction to health and safety, environmental, safe systems of work etc.
- Work place safety access, egress, emergencies, vehicles, equipment, machinery.
- Fire precautions and procedures.
- Accidents - prevention and reporting, first aid.
- Hazardous substances – Control of Substances Hazardous to Health (COSHH).

- Manual handling.
- Noise at work.

The training is delivered through a network of accredited training providers.

1.12 Legal requirement for noise awareness training

Specifically the Noise Regulations, 2007, outline that any worker exposed to a $L_{EX,\,8h}$ in excess of 80 dBA must be provided with

"suitable and sufficient information and training relating to the risks resulting from exposure to noise". (Irish Government, 2007).

It is uncommon for any legislation to stipulate what may be considered "suitable and sufficient". However, the Noise Regulations, 2007 specify the following topics to be contained in the information and training of employees:

- The nature of the risks as a result of noise in the workplace,
- The organisational and technical measures taken in order to reduce noise in the workplace to as low a level as is reasonably practicable,
- Exposure limit values and exposure action values,
- The results of noise assessments and their significance and potential risks,
- The correct use of hearing protection,
- Why and how to detect and report signs of hearing damage,
- Explain the purpose of audiometric testing and the circumstances in which it is made available to employees.
- Safe working practices that minimise exposure to noise (Irish Government, 2007).

Throughout the world, occupational noise legislation leaves employers some latitude with respect to program design, implementation, and administration. For example, they do not specify delivery method, duration, evaluation, or trainer qualifications (Prince *et al.*, 2004). To date no sector specific nightclub noise training courses have been identified in the literature. The requisite information/training is applicable whether the employee works in a nightclub or a noisy factory.

1.12.1 Noise awareness training in nightclub sector

It has not been established whether nightclub managers are unsure of how to train their employees on occupational noise awareness. Contacting the HSA for advice may not be a viable option since it has been found that small businesses are hesitant to contact the authorities on health and safety matters for fear of inspection (O’Hara and Dickety, 2000).

1.13 Attitudes, behaviour, safety climate and culture

An attitude can be defined as a learned tendency to react in a consistent way to a particular situation. The attitude of management and employees, in the management of safe behaviour are inter-dependant (HSE UK, 2002). With a life-time’s accumulation of “attitudes” within each of us we cannot expect to change them rapidly (Moss, 1991). Workplace attitudes are a key component of safe behaviour (Figure 1.3).

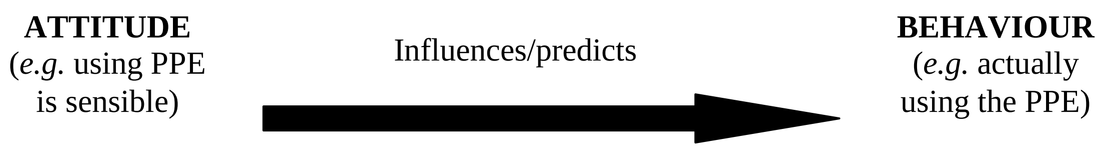


Figure 1.3: Adapted from Glendon and McKenna, 1995

Robinson (2005) pointed out that awareness of the risks of a particular behaviour may be quite high but this does not necessarily lead to effective behavioural change. It is necessary to change both an individual's behaviour *and* attitudes (Fishbein and Ajzen, 1975). The trainer should know as much as possible about the trainee's need and knowledge level. There is a significant association between people's health attitudes and their risk behaviour (Ajzen, 1991).

1.13.1 Safety climate

Health protection and hence behavioural change in the workplace will be more effective with management support (Schwerha, 2010). There is an increasing recognition that safety solutions which are based *solely* on engineering control measures and compliance with safety will fail if attitudes are poor (Zohar, 2006; Williamson *et al.,* 1997).

Workplace safety climate reflects the condition of the organisation. An employee may adopt the behaviours which they have observed from others in their workplace. These behaviours can then be further refined through self-corrective judgments based on information feedback from senior authority in the workplace (Bandura, 1977). Positive social reinforcement can be effective in improving the safety behaviour of employees (Sulzer-Azaroff and Austin, 2000).

1.13.2 Safety culture

Safety culture can be described as the atmosphere or culture in which safety is understood to be the number one priority (Cullen, 1990). During a review of safety culture theory and research Guldenmund described safety culture as '*the way we do things around here'* (2000).

Safety cultures will have an influence on safety climate and a good safety culture will be promoted and maintained by a "good" safety climate (Mearns *et al.,* 1998). Organisations with a positive safety culture are characterised by communication founded on mutual trust, by shared perceptions of the importance of safety and by the confidence in the efficiency of the preventative measures (Booth and Lee, 1995). The role of the supervisors and management is crucial if the adoptions of noise control measures by employees are to be successful. Hence the managers must also understand noise and its harmful effects.

The best safety cultures stem from organisations that adopt an attitude of "constructive intolerance" of unsafe and potentially unsafe conditions (Wright *et al.,* 1999). Arezes and Miguel (2008) found that the individual risk perception of employees appeared to be an important predictor of safe behaviour, particularly in the use of hearing protection. It has been suggested that workers' safety climate (perceived) plays an important role in increasing the percentage of safe actions (Zohar, 2006).

1.14 Successful noise awareness training

NIOSH in the US identified that the traditional "chalk and talk" approaches to occupational health and safety were not benefiting the application of Hearing Loss Prevention Programmes (NIOSH, 1998b). They recommended that more research should be carried out to develop programmes that involve employees in the noise risk assessment processes. In work based learning people learn best from practical experience in a way that is not possible from instruction or information delivery alone (Caine and Caine, 2006). Learning from experience involves critical reflection on the knowledge gained (Fenwick, 2003).

Knowles (1970) pointed out adults prefer problem centred learning and have a desire to apply their learning to real-life situations. Others have criticised Knowles for ignoring the effects of culture on learning and development (Merriam et al., 2007; Sandlin, 2005). The issue of safety climate and culture and the effects it may have on training and its effectiveness will be examined in further detail below.

1.14.1 The success of noise awareness interventions

The Royal New Zealand Air Force (RNZAF) increased noise awareness through the use of a DVD training aid which covers the types of noise sources specific to their sector. They also used case studies of members of a New Zealand rock band, one of whom had NIHL and another who had used hearing protection from an early age. They found that awareness levels were raised significantly and there was an increase in the number of hearing protectors purchased (Miller and Sparkes, 2009). Hearing protection policies issued by management were found to increase hearing protection use by fire-fighters (Ewigman *et al.*, 1990).

Noise training should not focus only on the use of hearing protection but be more widely aimed at the identification of sources of noise in the workplace and their minimisation (Williams *et al.*, 2007).

1.15 Risk perception and risk communication

Misinterpreted risks can lead employees to inappropriate behaviours (Bye and Lamvik, 2007). Arezes and Miguel (2006) found that risk recognition could have an important impact on noise exposure.

1.15.1 Using focus groups

Sadhra *et al.* (2002) noted that 75% of the employees in the 3 entertainment venues they studied claimed that they had not been issued hearing protection. Furthermore, 25% of those who were provided with ear defenders did not use them. No research related to the factors that have influenced nightclub employees to wear hearing protection has been published.

There is a need to develop evidence-based interventions that promote and support the proper use of hearing protection, especially in workplaces where other controls have not sufficiently reduced the noise hazard (Stephenson and Stephenson, 2011). Many studies related to hearing protection use in other industries have involved focus groups (Stephenson and Stephenson, 2011; Tantranont *et al.*, 2009; Abel, 2008; Prince *et al.*, 2004; Patel *et al.*, 2001). Focus groups allow employees to express the challenges and problems that exist in their workplace (Morata *et al.*, 2005).

Stephenson and Stephenson (2011) conducted focus groups with carpenters to develop an effective hearing loss prevention program for construction workers. The backbone of their research was the Health Belief Model (HBM). The rationale of using the HBM was that many studies have shown that the use of hearing protection is strongly influenced by the individual's belief that they can select suitable hearing protection and insert it correctly.

1.15.2 Using the Health Belief Model (HBM) to develop training

The HBM is the oldest health communication model (developed in the 1970's) and has a body of research to support its validity. There are 4 constructs that are related to behavioural responses to a health risk *e.g.* NIHL:

1. **Susceptibility** to a health hazard.
2. **Severity** of the health hazard to the individual and effect on quality of life.
3. **Benefits** of protective action and the effectiveness of protective measures.
4. **Barriers** to adopting protective actions and the ability to overcome the barriers.

The HBM was used successfully by researchers studying hearing protection use in construction and other industries (Stephenson and Stephenson, 2011; Neitzel *et al.*, 2008; McCullagh, Lusk and Ronis, 2002). The model used by the aforementioned authors for NIHL and hearing protection use was adapted because there are additional constructs that can be added to the HBM. Pender's Health Promotion Model (HPM) advances the HBM in relation to hearing protection use (Stephenson and Stephenson, 2011). The HPM adds the following constructs:

1. **Self efficacy** *i.e.* the individual's belief that they can select suitable hearing protection and insert it correctly.
2. **Interpersonal influences** from co-workers and social norms in the workplace.
3. **Situational influences** involving the availability of hearing protection in the workplace and the safety climate in the workplace.

A tailor-made noise training course, using the adapted HPM was designed and pilot-tested in the construction industry by Neitzel *et al.* (2008). They described the success of using adapted HPM as an appropriate theoretical model to assist the design of sector specific training. While they credited the HPM for assisting the design of suitable training for the construction industry the resulting behavioural changes, measured using a 5-point Likert scale, were not significantly different after training.

The backbone of Stephenson and Stephenson's (2011) research was the HBM, which was adapted to include HPM constructs to guide the development of noise awareness for training of apprentice carpenters. Another paper published by Stephenson evaluated the effectiveness of their evidence based training intervention delivered to 102 apprentice carpenters. After a follow up survey 1 year later, they showed that there was a significant difference between pre-post test HBM/HPM attitude scores and concluded that the HBM/HPM were extremely useful in developing effective training.

1.15.3 Risk communication

Risk communication is a two-way process. It is essential for risks to health to be communicated in a responsible and effective manner (Lum and Tinker, 1994). Care and attention must be paid to the way information relating to risks, such as noise at work, is conveyed (Gigenenzer, 2003).

1.15.3.1 Barriers to effective risk communication

A person can appear to be more tolerant of higher risk if the hazard is known to them (Leiss, 2004). Effective risk communication seeks to facilitate an informed understanding of risks (Frewer, 2004). As Taylor-Gooby (2004) noted, trust is central to risk communication.

1.16 The cost of hearing loss

It has been reported that workers with hearing loss are more likely to have an accident in work (Girard *et al.,* 2009; Choi *et al.,* 2005,). Persistent tinnitus may rapidly become a source of serious disturbance and disability (Tyler, 1993). Assessment of these disabilities reported strong correlation with sleep disturbance, irritability, depression and anxiety (Andersson *et al.*, 2002; Mrena *et al.*, 2002; Folmer, Griest and Martin, 2002). Males suffering from severe hearing loss are almost 30% more likely to be on permanent disability than normal hearing men.

"Preventing NIHL would do more to reduce the societal burden of hearing loss than medical and surgical treatment of all other ear diseases combined" (Dobie, 2001).

The HSE UK have estimated the cost impact of the reduction of the 3 dBA limit in employee noise exposure could save the health sector between £265 million and £582 million over ten years, rising to £1.6 billion over the next 40 years. This figure is based on an acceptance that not all employees will adhere to the legislation (Health and Safety Commission UK, 2004).

In Australia the cost of claims for hearing loss has varied between $3 million to $5 million from 2002-2007. In Australia the average cost of a compensation claim was approximately $7,000 (Government of Southern Australia, 2008).

1.17 Aim of project and objectives

The aim of this PhD is to use components of risk analysis to guide our exploratory study measuring current employees' noise exposure in Irish nightclubs, to examine nightclub compliance with their obligations under the legislation and examine the reasons for non-compliance. In order to achieve the aim of this research project the following specific research objectives have been outlined;

1. To determine amplified late night music venues employees' daily and weekly noise exposures.
2. Calculate the predicted hearing loss of employees based on their noise exposure.
3. Determine venues level of compliance with the Noise Regulations, 2007 and adherence to the HSA guidance document "Noise of Music".
4. Explore the challenges faced by authorities when enforcing the requirements of the occupational noise legislation.
5. Develop an effective noise awareness training programme that will target employee beliefs and barriers.
6. Investigate the safety culture in venues and the reasons for non-compliance to the Noise Regulations, 2007.

1.18 Chapter summary

Chapter 1 presented an introduction to sound and the process of hearing. It explained Noise Induced Hearing Loss (NIHL) and its impact on individuals. This chapter highlighted that NIHL is incurable but preventable (EAHSW, 2005).

The literature review pointed out that 2008 marked the commencement of a new era for noise control in the entertainment industry in Ireland due to the revision of the Noise Regulations, 2007. Similar changes have been adopted in other EU countries. In the UK the Health and Safety Commission have warned that if compliance with the revised exposure limit value cannot be met it could cost the health sector between £265 million and £582 million over the next ten years, rising to £1.6 billion over the next 40 years.

Chapter 1 examined the literature related to noise and its measurement in the nightclub industry. It further examined the requirements of Irish occupational noise legislation and described control measures outlined in the "Noise of Music" guidance document. The influence of safety culture on employees' attitudes was discussed. The review clearly showed that little research on occupational noise exposure in the nightclub industry has been carried out in Ireland.

This thesis is presented in chapters based on the three components of noise risk analysis: noise risk assessment, noise risk management and noise risk communication. Please see Appendix 1 for an overall summary of the alignment of the six PhD objectives with the of noise risk analysis objectives described in this thesis.

Chapter 2

METHODOLOGY

Noise Risk Assessment

2.0 Introduction

This project arose from previous undergraduate research carried out by the researcher (Kelly and Boyd, 2007). A lack of baseline data of nightclub employees' noise exposure in Ireland was identified. Funding was secured from the Irish Research Council (IRCSET) Embark Initiative in 2008 for 3 years and was extended to a 4 year project with the Dublin Institute of Technology (DIT) Fiosraigh, PhD scholarship extension scheme. Work on the project commenced November 2008 and ethical clearance was granted December 2008 for all risk analysis aspects of the research methodology.

2.1 Gaining access and selection of venues

A convenience sample of nightclubs was used. A meeting was held with the Chief Executive Officer (CEO) of the Irish Nightclub Industry Association (INIA) in February 2009. Following this meeting, the details of this research project were placed on the INIA website requesting the involvement of nightclub management and employees. The ethical issues relating to this project were also outlined *i.e.* confidentiality of the results and the ability of the nightclub manager and employees to withdraw from the research at any stage. For a copy of the document please refer to Appendix 2.

A list was created of the nightclubs in Leinster. This was used to track the contact made with nightclub managers. The list of nightclubs was compiled from:

1. A Google internet search of nightclubs in Leinster.
2. Search engine websites www.entertainment.ie and www.indublin.ie were viewed for details of nightclubs in Leinster.
3. Newspapers from the Leinster region were searched online for advertising related to nightclubs operating.

4. The INIA membership list for Leinster was used to carry out internet searches to find contact details for the nightclubs.
5. A LinkedIn profile was created to describe the research project to LinkedIn contacts instigating the call for nightclub participation in the research in September 2011.

A nightclub was classed as suitable if it satisfied the following criteria:

1. It was a licensed venue which served alcohol and opened to the public after 22:00.
2. A Disc Jockey (DJ) was present, playing pre-recorded amplified music.
3. It had a dedicated dance-floor area.
4. An admission fee was charged at the door.
5. It had a Special Exemption Order (SEO).

The nightclub manager was approached and the project was outlined. A follow up email explaining the project was sent to the manager and this was followed by a phone call. A date to visit the nightclub was arranged. The aim was to recruit 20 nightclubs. A copy of the Health and Safety Authority (HSA) guidance document was supplied to each manager.

2.1.1 Inclusion of discobar venues in fieldwork

During the fieldwork stage of this research changes were occurring in the nightclub industry in Ireland. Numerous nightclubs were affected by the recession and began to waive their admission fee. Many had ceased operation or had changed to playing live music. Premises that did not charge an admission fee were classed as discobars. While the initial research proposal specifically referred to nightclubs, the inclusion of discobars was essential to provide a reasonable sample number. A discobar was deemed suitable for inclusion if it satisfied the following criteria:

1. It was a licensed venue which served alcohol and was listed on the INIA website as a member.
2. A DJ was present, playing pre-recorded amplified music.
3. It had a dedicated dance-floor area.
4. It had a Special Exemption Order (SEO).

2.1.2 Visits to venues

The first fieldwork visits were conducted in 7 nightclubs/discobars (hereinafter venues) from May to August 2009. A further 8 venues were visited from March to November 2010 and five more between October and November 2011. The initial visits were conducted on the busiest nights as identified by the managers. Ten of the participating venues were located in Dublin's city centre and the remaining 10 were in towns in the Leinster area.

Note: Revisits where conducted on two occasions for 15 of the venues from May to November 2011. One of the revisits was on the same weekday as the initial visit. The other revisit was on a night where the manager expected the venue to be less busy. The days ranged from Wednesday to Monday. The purpose of the revisits was two-fold, firstly they were used to examine whether re-measurement led to a difference in noise exposure for employees and secondly to explore the influence of less busy nights on the cumulative weekly noise exposure of employees.

2.2 Risk assessment – Noise hazard identification

To identify the health risks due to noise exposure, the initial step was to identify the sources of noise in the venues and estimate the hours for which employees were exposed to noise. Figure 2.1 illustrates the use of manager interviews and employee questionnaires to achieve the initial step of hazard identification.

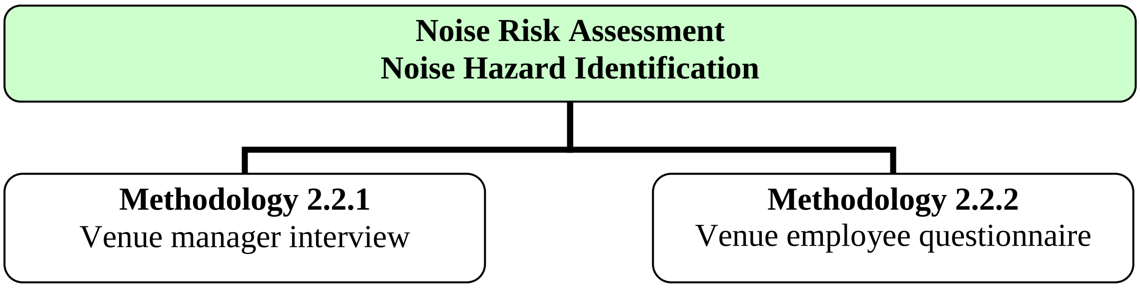


Figure 2.1: Noise Risk Assessment: Noise Hazard Identification.

2.2.1 Venue manager interview

To identify the means by which noise arises in amplified music venues a structured management interview was conducted face to face (for 30 minutes) with venue managers during the initial visit to their venue. The interview was used to:

1. Provide demographic information on the manager (including qualifications).
2. Determine the trading hours of the venue and type of music played in the venue.
3. Investigate the number of hours worked by venue employees in a week.

The management interviews were designed based on similar questions used in previous studies in amplified music venues: Bray *et al.*, (2004); Sadhra *et al.*, (2002); Whitfield (1998). Pilot testing was conducted with two nightclub managers to ensure validity of the open ended and close ended questions. For a copy of the venue manager structured interview please refer to Appendix 3.

2.2.2 Venue employee questionnaire

A 34 item noise questionnaire was designed, and distributed to all employees present while the researcher was in the participating venues. The questionnaire was completed by the employees prior to their work-shift commencing and was designed to take 15 minutes to complete. Section 1 of the noise questionnaire for venue employees was used to:

1. Provide demographic information about the employee including age and number of years working in the nightclub/discobar industry.
2. Determine the time spent by employees at each work location/task including work breaks.
3. Determine the weekly work patterns for the employees. In addition, it gathered information regarding other employment and other sources of noise exposures.

The employee questionnaires were designed based on questions used in previous studies in amplified music venues: Bray *et al.*, (2004); Sadhra *et al.*, (2002); Whitfield (1998). Pilot testing was conducted with 10 nightclub employees to ensure validity of the open ended and close ended questions. For a copy of the venue employee noise questionnaire please refer to Appendix 4.

2.2.3 Statistical analysis of noise hazard identification data

All noise hazard identification data was entered for statistical analysis. Independent T-tests were carried out to make comparisons between the nightclubs and discobars operating hours and their employee demographics. Non-parametric Mann-Whitney U Tests were conducted on the venues design features. Differences between categorical data were analysed using chi-squared analysis *e.g.* testing for a significant association between age categories and owning an MP3 player. Statistical significance was assumed at the $p < 0.05$ level.

2.3 Risk assessment – Noise hazard characterisation

According to the HSE (2002), it is not adequate to assess the noise exposure of employees in music venues by simply measuring noise levels on the dance-floor (Smeatham, 2002). For this reason, the application of noise hazard characterisation, involved the use of dosimeters and 2 sound level meters (SLM) to accurately estimate the noise exposure of employees. As shown in Figure 2.2, 4 methodologies were used to assess the typical noise levels experienced by venue employees.

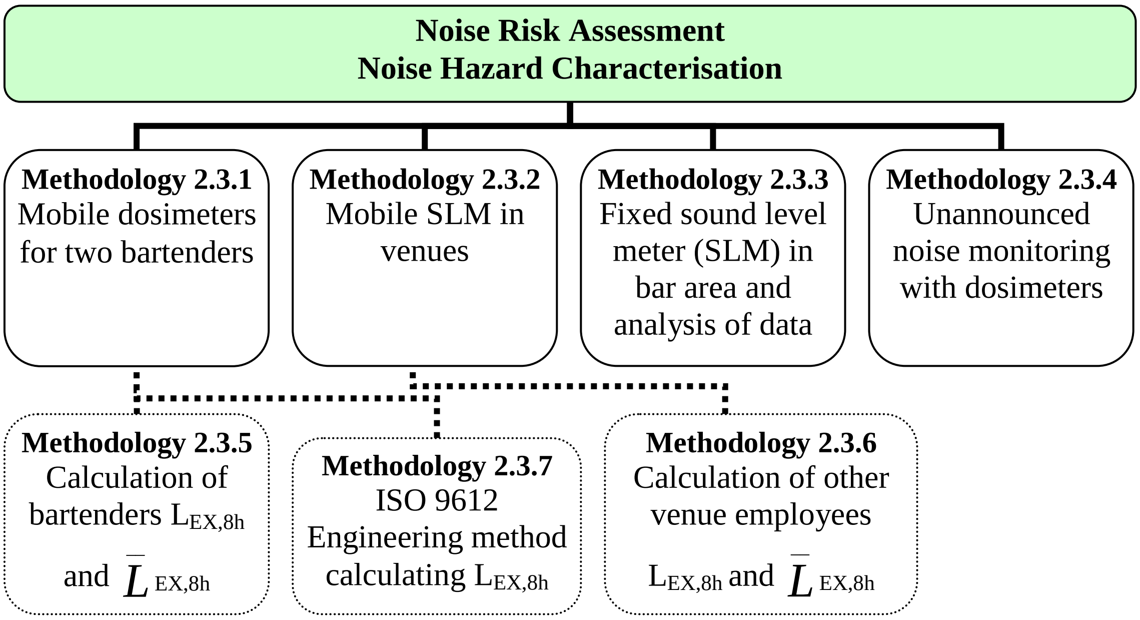


Figure 2.2: Noise Risk Assessment: Noise Hazard Characterisation

Additional methodologies were also used to assist in the calculation of daily and weekly noise exposure of venue employees (as depicted by the dashed lines in Figure 2.2).

2.3.1 Use of dosimeters to measure noise exposure of bartenders

Two tamper-proof type 2 dosimeters (Bruel and Kjær 4445E) were attached to 2 bartenders in each of the participating venues. Fifteen of the venues had noise monitoring carried out over an additional 2 nights in order to take into account the variation in noise levels on different nights.

2.3.1.1 Configuring measurement set-up

Prior to the fieldwork being carried out, the dosimeters were connected to the computer via a type AO0577 serial interface cable. Type 7825 Protector Software was run on the computer and the following measurement parameters were set up as a result of the manufacturer's recommendations when measuring occupational noise exposure:

- Range: 70-140 dBA.
- Time weighting: Fast.
- Frequency weighting: A-weighting.
- Frequency weighting for peaks: C-weighting.
- Exchange rate: 3 dB.
- Threshold: 70 dBA.
- Criteria level: 85 dBA.
- Logging: Every 1-minute.

2.3.1.2 Calibration of dosimeters

To provide confidence in the noise levels measured, calibration of the dosimeters was essential. Upon purchase, the dosimeters were laboratory calibrated to British Standard (BS) 7580: Part 1: 1997. Please refer to Appendix 5 for a sample of the Bruel and Kjaer calibration certificate. Laboratory recalibration after 2 years was also carried out. Field calibration of dosimeters was carried out to manufacturer’s instructions before and after use in each venue, as per the guidance in International Organisation for Standardisation (ISO) 9612:2009.

2.3.1.3 Bartenders noise measurement in venues

The manager was asked to indicate those bartenders who would be working in the bar closest to the dance-floor for the night in question. Two bartenders were then approached and asked if they would wear the dosimeters. Dosimeters were attached at the earliest stage of the bartenders’ work-shift, to allow noise measurements to be taken during different activities *i.e.* stocking bar, sound check and during operation of the venue. At a minimum, continuous 1-minute $L_{Aeq,T}$'s were recorded between the hours of 23:30 and 01:00. Two bartenders in each venue wore a tamperproof type 2 dosimeter (Brüel and Kjær 4445E), apart from Club D, where only 1 bartender was available.

The 2 chosen bartenders were shown how to securely attach the dosimeter onto their belt. The microphone was then attached to the employees shoulder, approximately 10cm from the ear. The microphone was facing forwards (see Figure 2.3). The bartenders were asked to behave as usual in their workplace.

Figure 2.3: Dosimeter microphone attached to bartenders shoulder.

Once the dosimeters were started the keypad was locked and the bartenders resumed their normal duties. At 01:00 the dosimeter was unlocked, measurements were stopped and the dosimeters were recalibrated. The day after fieldwork measurements were carried out, the dosimeters data was transferred to type 7825 Protector Software.

2.3.2 Measuring noise exposure of employees in other roles in the venue

The variation in noise exposure of employees in other roles in the venues (hereinafter other venue employees) was measured using a mobile type 1 integrated SLM (Bruel and Kjaer 2238 Mediator. The mobile SLM was used to carry out numerous 5-minute average sound level ($L_{Aeq,Ti}$) samples during revisits to the venues. The mobile SLM measured the other venue employees noise exposure *e.g.* glass collector, cloakroom/cash desk attendant, DJ, security personnel and bartenders working in other bars, during the operation of the venue. Please see Figure 2.4 for a depiction the mobile SLM used.

Figure 2.4: Digital read out on the 2238 mediator mobile SLM

2.3.2.1 Measurement parameters

The following measurement parameters were set according to the manufacturer's recommendations and were influenced by previous similar studies in amplified music venues (Sadhra *et al.*, 2002; Whitfield, 1998):

1. The range of sounds to be recorded was set from 60-140 dBA.
2. A-weighting sound pressure level was selected.
3. Time weighting was set to FAST.
4. L_{Cpeak} was selected for C-weighted peak sound pressure level.
5. The tolerance level was set to 0.5 dB and the windscreen correction was on.

2.3.2.2 Calibration of mobile SLM

The mobile SLM was laboratory calibrated every 2 years during the fieldwork phase. The mobile SLM was set up directly from the keypad interface on the SLM body. Field calibration of the mobile SLM was carried out to manufacturer's instructions before and after use in each venue, as per ISO 9612:2009.

2.3.2.3 Mobile SLM noise measurement in the venue

In 15 venues, multiple 5-minute sound levels ($L_{Aeq,T}$) were recorded in 4 to 6 working locations each night. The locations corresponded to the positions occupied by other venue employees *e.g.* cloakroom or cash desk, security personnel' position at the edge of the dance-floor or the DJ box. As per the requirements of ISO 9612:2009, the mobile SLM microphone was held at head height. In the case of the DJ and the cloakroom/cash desk staff, the mobile SLM was used to identify which ear was exposed to the highest L_{Aeq} and the microphone was held 40cm from the most exposed ear while the employee continued their role in the venue (ISO, 2009). In the bar(s) away from the dance-floor, the mobile SLM was held at head height at the centre of the bar since it was not feasible to stand behind the counter due to the movement of the bartenders. To measure the noise exposure of glass collectors the mobile SLM was held at head height and a similar path to that of a glass collector was navigated though the venue. Each 5 minute noise measurement was saved in the mobile SLM under a unique file number. To keep track of files, a record was taken in a notebook that linked the mobile SLM file number to its corresponding measurement location in the venue. The day after fieldwork measurements were carried out, the mobile SLM data was transferred to the type 7825 Protector Software.

2.3.3 Fixed SLM in bar area closest to dance-floor

Concurrently with the dosimeter and mobile SLM noise measurements in the venues, another type 1 integrated SLM (Bruel and Kjaer 2238 Mediator) was placed in a fixed position in the bar area closest to the dance-floor. The fixed SLM measured the L_{Aeq} in the bar area over time. It also simultaneously measured the L_{Aeq}'s in the 8 different octave bands.

2.3.3.1 Measurement parameters for the fixed SLM

The fixed SLM was set up with the same settings as described in section 2.3.2.1 above except for the following additions:

1. The octave band width was set to 1/1 octave.
2. The octave band limits were set to 31.5-8000 Hz.
3. Number of scans of the frequency bands was set to 30. This was set to measure for 8.5 minutes: a time which was assumed to be longer than the duration of 1 song and thus ensuring that the different frequencies a single song played during the measurement.
4. The dwell time was optimised. This ensured that the fixed SLM was able to ensure the same tolerance for all measured frequency bands.
5. The correction filter for the microphone was set to frontal and windscreen correction was on.

2.3.3.2 Calibration of fixed SLM

Calibration of the fixed SLM was carried out in the exact same manner as for the mobile SLM, (see section 2.3.2.2).

2.3.3.3 Fixed SLM noise measurement in the venue

Once inside the venue, the bar area closest to the dance-floor was identified. The fixed SLM was protected in a tamperproof case away from the activities of the bar and a 10m microphone extension cable was connected to the fixed SLM. During microphone positioning consideration was given to factors which might affect the results such as surface reflections and accidental or deliberate tampering. A windscreen was placed over the fixed SLM microphone to help prevent accidental damage and knocking. The microphone was placed in a fixed position behind the bar using a flexible tripod approximately 1.55m ± 0.075m above ground level as per ISO 9612. The fixed SLM was switched on at 23:30, at 00:15 and again at 01:00 for 8.5 minutes and each time recorded 30 samples of each 1/1 octave band, in dB. The fixed SLM was also used to calculate a representative L_{Aeq} in the bar area over the 3 time periods, on each of the monitoring days to establish the noise level trend for each venue (Whitfield, 1998). The day after fieldwork measurements were carried out, the fixed SLM data was transferred to the type 7825 Protector Software.

2.3.3.4 Analysis of fixed SLM data

Bruel and Kjaer 7825 Protector Software was used for post processing of the gathered noise data taken from the fixed SLM. The software ultimately downloaded the measured data into the folders for each venue and enabled analysis to be carried out on the octave bands and the noise level trend L_{Aeq}. Screening of the fixed SLM results was carried out in the following steps:

1. After transferring the fixed SLM data the following chart was generated, as per Figure 2.5.

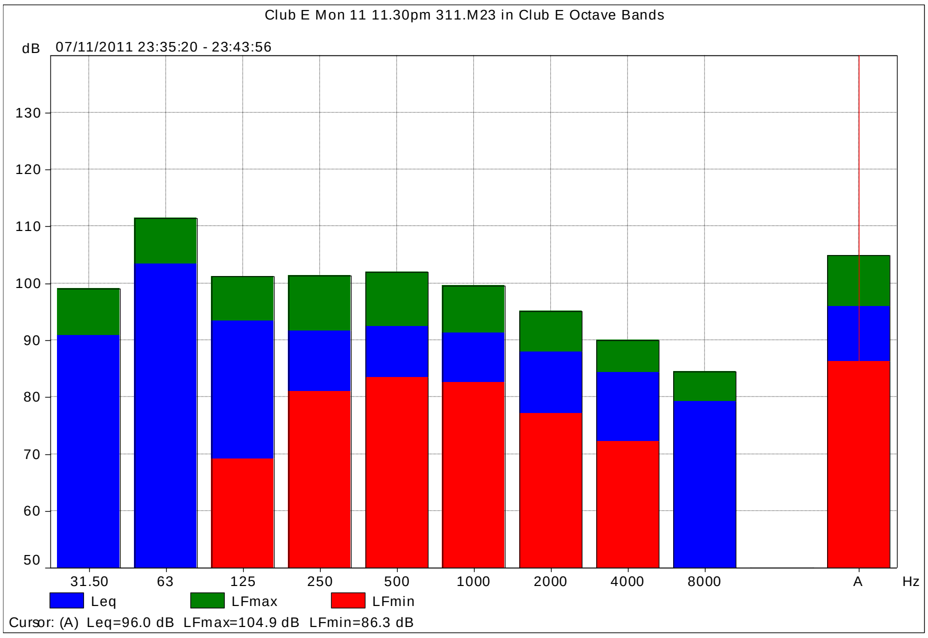


Figure 2.5: 7825 Protector screen for fixed SLM octave band measurements.

Blue columns represent the L_{eq} for each octave band from 31.5-8000Hz. The final column shows the overall L_{Aeq} reading for the measurement (read from the top of the blue column).

2. The L_{Aeq} points for each frequency were read from the graph and entered into Microsoft Excel. This was carried out for each of the fixed SLM noise measurements taken *e.g.* 23:30, 00:15 and 01:00.
3. The maximum L_{Aeq} for each frequency was also recorded for later use when selecting the most suitable hearing protection. More details are provided on this method in Chapter 3, section 3.2.1.1.

2.3.4 Unannounced noise monitoring

A control group was used to account for the noise levels in venues when management were not aware that noise measurements are taking place. Ethical clearance was obtained from DIT ethics committee, in 2011, to carry out noise measurements without prior consent from management during unannounced visits within 10 venues in Dublin that were not previously involved in the research. It was necessary that each venue satisfied the criteria set out for classification as a nightclub or discobar as outlined in Sections 2.1 and 2.1.1 of this chapter. Venues were selected from a list of venue managers that were supportive but did not wish to participate in the fieldwork aspect of the research.

In December 2011, to approximate the bartenders exposure, 2 dosimeters were used to measure the L_{Aeq} and L_{Cpeak} in the bar area closest to the dance-floor. Measurement parameters were set to be the same as for the dosimeters originally attached to bartenders. Both dosimeters were field calibrated, locked and each microphone attached to the shoulder of the researcher and a companion prior to entering the venue. A position was taken at the mid-point of the bar area closest to the dance-floor from 23:30

to 01:00. Notes were made on design features in the venue and any other incidents that may have occurred during the measurement. Data was transferred from the dosimeters the following day into a coded folder *e.g.* "Unannounced visit 1".

2.3.5 Analysis of bartender dosimeter data and calculation of $L_{EX,8h}$ and $\overline{L}_{EX,8h}$

Bruel and Kjaer 7825 Protector Software was used for post processing of the gathered noise data taken from the 2 dosimeters. This software downloaded the measured data into noise profile folders for each venue. The following section of the methodology shows how the noise data was analysed and a figure for $L_{Aeq,T}$ (continuous A-weighted sound pressure level that represents the sound that a bartender was exposed to during a given period) was calculated.

2.3.5.1 Screening dosimeter results

1. After transferring the dosimeter results Figure 2.6 was generated;

Figure 2.6: Example of the 7825 Protector screen for dosimeter results

2. The coded details of the venue and the bartenders were attached to the noise measurement folder on the software for identification purposes.

3. Each venue had a folder assigned to it which was used to gather the 2 bartenders' dosimeter results and the mobile SLM measurement data. Each bartender had a **Person** file individually created for them.
4. Both bartenders noise profiles were compared to each other to ensure L_{Cpeak} measurements were representative of the noise experienced by the employees and that the L_{Cpeaks} were as a result of noise experienced by the bartenders rather than impacts on the microphones. If a L_{Cpeaks} appeared on 1 dosimeter but did not appear on the other dosimeter it was **"excluded"** from the overall measurement results in order to give a more representative $L_{Aeq,T}$. The exclusions are shown below in red at the top of the noise measurement, as per Figure 2.7.

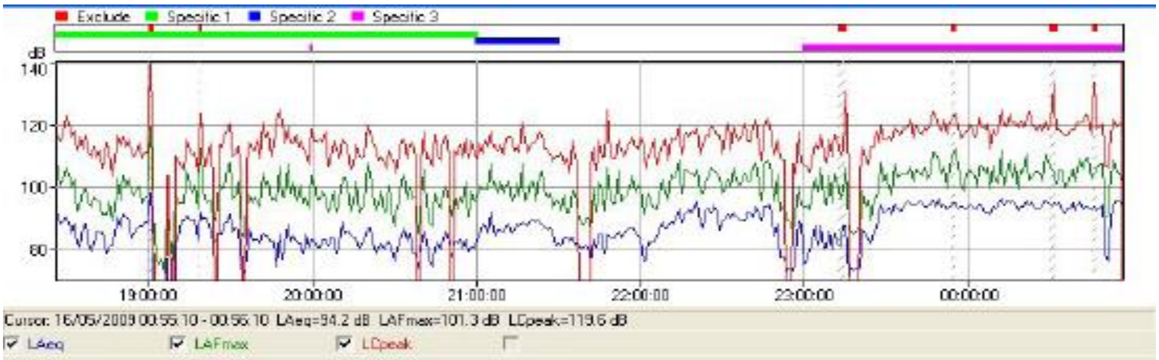


Figure 2.7: Protector screen when peak measurement data was excluded as it was not representative of the noise experienced by the bartenders.

5. Since the researcher was present at the venue while the bartenders were wearing the dosimeters it was possible to record the periods when they were: stock-taking when no music was playing (denoted as specific 1), when stocking the bar while the DJ sound checked (denoted as specific 2) as well as during venue operation with music playing (denoted as specific 3). Consequently, it was possible to isolate the noise measurements at these individual times ($L_{Aeq,T}$) in

order to calculate $L_{EX,8h}$. This can be seen in the noise measurement graph below in Figure 2.8 where **"specific"** time periods 1-3 are marked at the top of the graph in coloured bars of green, blue and pink.

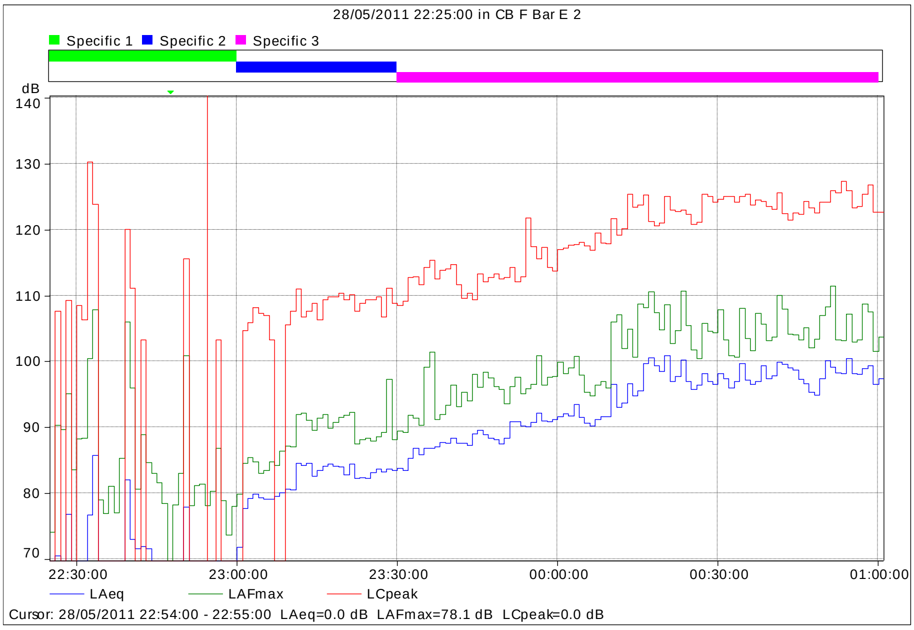


Figure 2.8: Protector noise graph marked with the tasks carried out by bartenders: stocktaking when no music was playing (denoted as specific 1), when stocking bar while the DJ sound checked (denoted as specific 2) as well as during venue operation with music playing (denoted as specific 3).

6. Table 2.1 shows an example of the data recorded for a bartender wearing the dosimeter which were used to calculate the bartenders $L_{EX,8h}$. The calculated $L_{EX,8h}$ was then compared with the exposure limit value of 87 dBA and lower/upper exposure action values, set by the Noise Regulations, 2007.

Table 2.1: 7825 Protector output of $L_{Aeq,T}$ results for 3 specific tasks

	Name	Start time	Elapsed time	L_{Aeq} (dBA)
1	Total	15/05/2009	5:05:00	89.5
3	Specific 1	15/05/2009	02.34:00	85.5
4	Specific 2	15/05/2009	00:31:00	87.2
5	Specific 3	15/05/2009	1:58:00	92.8

2.3.5.2 Numerical analysis - calculating bartender $L_{EX,8h}$ and $\overline{L}_{EX,8h}$

The formulae for $L_{EP,\,d}$ (equivalent of $L_{EX,\,8h}$) and $L_{EP,\,w}$ (equivalent of $\overline{L}_{EX,8h}$) defined by ISO 1999:1990, were utilised (Health and Safety Executive (HSE UK), 2005), shown in Figure 2.9 and Figure 2.10. The $L_{EP,d}$ calculation was chosen based on the fact that the bartenders worked in 3 different sound level environments over the course of their shift. Therefore, the nightclub bartenders daily exposure consisted of 3 average sound levels as they carried out the following tasks;

- Bar stocking when no music was playing,
- Bar stocking during DJ sound check and
- Serving customers from behind the bar while the music was playing.

The discobar bartenders had slightly different tasks:

- Serving customers with low background music playing during the day until 21:00.
- Serving customers between 21:00 and 22:30 an increase in ambient background music.
- Serving customers while the DJ played music.

$$L_{EP,d} = 10\log_{10}\left[\frac{1}{T_0}\sum_{i=3}^{i=n}(T_i 10^{0.1\times L_{Aeq,T}})i\right] dBA$$

Figure 2.9: Formula used to estimate bartenders daily noise exposure (HSE, 2005)

Where:

T_0 = number of seconds in an 8 hour working day (28,800s),

i = time period of the sampling,

n = the number of individual periods in the working day,

T_i = the duration of period i;

$L_{Aeq,T}$ = the equivalent continuous A-weighted sound pressure level that represents the sound the person is exposed to during the sampling period, i,

Worked Example;

The following $L_{Aeq,T}$ was recorded by a nightclub bartender's dosimeter in Club D;

- 82 dBA when bar stocking, no music playing = 3600s (1 hour)
- 84.9 dBA when bar stocking during sound check = 1800s (0.5 hours)
- 98.3 dBA when serving customers from behind the bar = 10800s (3 hours)

$$L_{EP,d} = 10\log_{10}\left[\frac{1}{28800s}\sum_{i=3}^{i=n}\left(\left(3600s\times 10^{0.1(82)}\right)+\left(1800s\times 10^{0.1(84.9)}\right)+\left(10800s\times 10^{0.1(98.3)}\right)\right)\right] dBA$$

$$L_{EP,d} = 10\log_{10}\left[\frac{1}{28800s}\times(7.41\times 10^{13})\right] dBA$$

$L_{EP,d} = 94.1$ dBA = Employee daily exposure limit value.

The $L_{EP,\,w}$ ($\overline{L}_{EX,\,8h}$) was utilised for part-time bartenders who worked for 3 nights per week, as shown in Figure 2.10. This formula was applied to the 15 venues that were revisited.

$$L_{EP,w} = 10\log_{10}\left[\frac{1}{5}\sum_{i=1}^{i=m} 10^{0.1(L_{ep,d})}\, i\right]$$

Figure 2.10: Formula used to estimate bartenders weekly noise exposure (HSE, 2005)

Where:

m = number of working days for which the person is exposed to noise during a week,

$(L_{EP,\,d})i$ = is the $L_{EX,8h}$ for working day i.

The following is a worked example to calculate the $\overline{L}_{EX,8h}$ of a part-time nightclub bartender who worked 3 nights per week when $L_{EX,8h}$ = 94.1 dBA;

$$L_{EP,w} = 10\log_{10}\left[\frac{1}{5}\sum_{i=1}^{i=3}\left(10^{0.1(94.1)} + 10^{0.1(94.1)} + 10^{0.1(94.1)}\right)\right]\text{dBA}$$

$$L_{EP,w} = 10\log_{10}\left[\frac{1}{5}\times\left(7.71\times10^{9}\right)\right]\text{dBA}$$

$L_{EP,w}$ = 91.9 dBA Employee weekly exposure limit value.

2.3.6 Analysis of other venue employee mobile SLM data and estimation of $L_{EX,8h}$ and $\overline{L}_{EX,8h}$

Bruel and Kjaer 7825 Protector Software was also used also for post processing of the noise data taken from the mobile SLM. The software downloaded the data into the pre-made venue folders from stage 2.3.5. Within each venue file the individual mobile SLM files were assigned to "location" folders corresponding to the location of the measurement in the venue. Each mobile SLM file contained data on the L_{Aeq} and L_{Cpeak} from the 5-minute measurement, along with overload percentage details *i.e.* when the noise exceeded 140 dBA. The time of the measurement, L_{Aeq} and L_{Cpeak} for each mobile SLM file were read from each venue folder and location and entered into Microsoft Excel.

2.3.6.1 Numerical analysis estimating other venue employees $L_{EX,8h}$ and $\bar{L}_{EX,8h}$

The noise levels of other venue employees were gathered using 5-minute samples (see section 2.3.2). As a result, the other venue employees daily noise exposure ($L_{EX,8h}$) was estimated using a different ISO 1999:1990 formula than the bartenders (see section 2.3.5.2). The ISO 1999:1990 is used is shown in Figure 2.11

$$L_{Aeq,T} = 10\log\left[\frac{1}{T}\sum_{i=1}^{n}(T_i \times 10^{0.1L_{Aeq,Ti}}\right]$$

Figure 2.11: Formula used to estimate other venue employees daily noise exposure (ISO, 1990)

Where:

T = Time period over which the average is taken *i.e.* the duration of the work-shift.

$L_{Aeq,T}$ = the equivalent continuous A-weighted sound pressure level, in decibels, averaged over time interval T_i.

The other venue employees $\bar{L}_{EX,8h}$ was estimated using the same formula presented in section 2.3.5.2 of this methodology chapter.

2.3.7 Application of ISO 9612:2009 to calculate employee $L_{EX,8h}$

The ISO 9612: 2009 “Acoustics – determination of occupational noise exposure - engineering method” (hereinafter Engineering $L_{EX,8h}$) was used to calculate the noise exposure of bartenders working in the bar closest to the dance-floor. This method was not suitable for comparison between Irish amplified music venues and their international counterparts in the literature as no other study had used Engineering $L_{EX,8h}$ to calculate daily noise exposure. The calculation of bartenders noise exposure using this Engineering $L_{EX,8h}$ method was necessary to estimate the long-term risk of hearing impairment using ISO 1999:1990.

2.3.7.1 Work analysis

ISO 9612 requires that work analysis is carried out prior to noise monitoring. For the purpose of this project the following methods were utilised to conduct the work analysis in the subgroup of 15 venues where 3 nights of dosimeter noise monitoring took place:

1. Using the data collected from employee questionnaires and manager interviews it was possible to define homogenous noise exposure groups.
2. The questionnaires and interviews were used to estimate a nominal work day in each venue and identify the tasks that made up the role of bartender in each venue. All tasks were assigned a duration and the noisiest work area *i.e.* the bar area closest to the dance-floor was assumed to represent the worst-case scenario.
3. Carrying out preliminary noise measurements in 2009 and 2010 in the venues aided the selection of a suitable measurement strategy.

2.3.7.2 Selection of measurement strategy

There are 3 measurement strategies suggested by ISO 9612, namely, task based measurements, job based measurements and full day measurements. Due to the health and safety restrictions, placed on the researcher's fieldwork, full day measurements were not possible as this would have required the researcher to be present in the venues until 03:00. The job based measurement strategy could not be used as the homogenous group "bartenders in bar closest to dance-floor" was never larger than 5 people. From Table 1 in ISO 9612, the minimum cumulative duration of measurement was 5 hours.

Bartenders generally did not have a 5 hour work period that would permit the measurement of noise for this time. As a result it was deemed most satisfactory to select task-based measurement to determine Engineering $L_{EX,8h}$ for bartenders.

2.3.7.3 Task based measurements

The venue bartenders' nominal day was divided into 3 tasks each of specific duration, as shown in Table 2.2. Both nightclub and discobar employees were treated in the same manner even though the discobar employees may have worked prior to 21:00. This was deemed appropriate since daytime measurements in the discobars showed that the noise levels only rose above 70 dBA after 21:00 and hence had a negligible effect on the overall noise exposure of the employee.

Table 2.2: Example of a bartender's nominal day

Task	Duration range (h)
Stocktaking in venue	0.25-2.0
Setting up bar while DJ sound checks	0.5
Working in bar while venue operates	3.0
Note: The time spent at each task was estimated from interviews with managers, questionnaires from employees and observations made while conducting the noise measurements in the venues.	

2.3.7.4 Example of calculation of task based Engineering $L_{EX,8h}$ measurements

The data gathered from the dosimeters measurements from May 2009 until November 2011 were processed to deliver multiple 5-minute samples from each task carried out by the bartenders. The following steps were carried out to create a database of the Engineering $L_{EX,8h}$ for bartenders:

Step 1: The 5-minute $L_{p,AeqT}$ samples were selected from dosimeter data.

Step 2: $L_{p,AeqT}$ samples were input into Excel rows for each task, dosimeter and venue. A code was entered into a column to highlight the maximum $L_{p,AeqT}$ level measured during the task for each row.

Table 2.3: Excel view of the $L_{p,AeqT}$ samples

Club		Date	Dosemeter	Task	Time1	LAEQ1	AVG1	Time2	LAEQ2	AVG2	Time3	LAEQ3	AVG3
5	5	26/06/2009	D1	1	**21.00**	69.7		**21.10**	77.9	Yes	**21.15**	79.3	Yes
5	5	26/06/2009	D1	2	**23.00**	90.7	Yes	**23.05**	90	Yes	**23.10**	88.9	Yes
5	5	26/06/2009	D1	3	**23.30**	50		**23.45**	95.5		**0.00**	95.4	
5	5	26/06/2009	D2	1	**21.00**	73.6		**21.10**	0		**21.15**	64.7	
5	5	26/06/2009	D2	2	**23.00**	93	Yes	**23.05**	95.1	Yes	**23.10**	89.6	
5	5	26/06/2009	D2	3	**23.30**	91.2		**23.45**	92.8		**0.00**	97.3	Yes

Step 3: An "IF" formula was used to highlight $L_{p,AeqT}$ samples within 3 dBA of each other. Excel cells highlighted in a red "Yes". This was repeated for each task. If the measurements were not within 3 decibels then the second highest L_{Aeq} was checked to see if there were 2 other L_{Aeq} levels that were within 3 dBA. If there were not 3 $L_{p,AeqT}$ samples within 3 dBA of each other, 6 $L_{p,AeqT}$ samples were included in the calculations ($L_{p,AeqT1}$ = Value 1-6).

Step 4: The $L_{p,AeqT,mi}$ (Val 1-3) and task duration (Len Time) were manually entered into 298 rows in Excel, as shown in Table 2.4 below.

Table 2.4: Excel view of the $L_{p,AeqT,mi}$ samples and duration of task (Len Time)

Task	Val 1	Val 2	Val 3	Len Time
1	80.1	79.5	79.3	2.0
2	90.7	89.5	90.0	0.5
3	98.5	97.4	95.5	3.0

Step 5: The A-weighted equivalent continuous sound pressure level ($L_{p,AeqT}$) was calculated for each task using the 3 (or 6) values from each row as per ISO 9612 the formula shown in Figure 2.12.

$$L_{p,A,eqT,m} = 10\log\left(\frac{1}{I}\sum_{i=1}^{I}10^{0.1xL_{p,A,eqT,mi}}\right)dB$$

Figure 2.12: Formula used to calculate the bartenders A-weighted equivalent continuous sound pressure level (ISO, 2009)

Where

$L_{p,A,eqT,mi}$ = The A-weighted equivalent continuous sound pressure level during a task of duration T_{mi};

m = task number

i = The number of task sample m;

I = The total number of task samples m.

In Excel the following formula was used to carry out this calculation;

```
=10*LOG(1/3*((POWER(10,Val1*0.1))+(POWER(10,Val2*0.1))+(POWER(10*V
al3*0.1)))
```

Step 6: The contribution from each task calculated in Step 5 to the daily noise exposure level ($L_{EX,8h,m}$) was calculated using the ISO 9612 formula, as shown in Figure 2.13.

$$L_{EX,8h,m} = L_{p,A,eqT,m} + 10\log\left(\frac{\bar{T}_m}{T_0}\right)dB$$

Figure 2.13: Formula used to calculate the bartenders $L_{EX,8h,m}$ (ISO, 2009)

Where

$L_{p,A,eqT,m}$ = The A-weighted equivalent continuous sound pressure level for task *m i.e.* the result from step 5.

$\bar{T}_m$ = The duration of task *m i.e.* as highlighted in step 4.

T_0 = The reference duration, *i.e.* an 8 hour working day.

In Excel, the following formula was entered to carry out this calculation for each task;

= $L_{p,AeqT}$ +10*LOG(task duration/8)

Step 7: The daily A-weighted noise exposure level ($L_{EX,8h}$) was calculated using the ISO 9612 formula shown in Figure 2.14 below for each bartender based on the contribution of each task in step 6.

$$L_{EX,8h} = 10\log\left(\sum_{m=1}^{M} 10^{0.1xL_{EX,8h,m}}\right) dB$$

Figure 2.14: Estimation of bartenders Engineering $L_{EX,8h}$ (ISO, 2009).

Where

$L_{EX,8h,m}$ = The A-weighted noise exposure level of task m calculated in Step 6.

m = The task number

M = Is the total number of tasks contributing to the daily noise exposure level.

In Excel, the following formula was entered to carry out this calculation for $L_{EX,8h}$;

= 10*LOG(POWER(10,TaskAvg1*0.1) +(POWER(10,Task Avg2 *0.1)) + (POWER(10, Task Avg3*0.1))

Step 8: The arithmetic average ($\bar{L}_{p,A,eqT,m}$) of the 3 (or 6) measured values from Step 4 ($L_{p,AeqT,mi}$) was calculated for each task. In ISO 9612, as shown in Figure 2.15 the formula for this equation was;

$$\bar{L}_{p,A,eqT,m} = \frac{1}{I}\sum_{i=1}^{I} L_{p,A,eqT,mi}$$

Figure 2.15: Calculation of the bartenders arithmetic average for tasks (ISO, 2009)

Where

$L_{p,A,eqT,mi}$ = The A-weighted equivalent continuous sound pressure level during a task of duration T_{mi};

i = The number of the task sample

I = The total number of task samples

In Excel the following formula was entered to carry out this calculation;

```
= (Val1+Val2+Val3)/3
```

Step 9: The standard uncertainty ($u_{1a,m}$) due to the sampling of a task (*m*) *e.g.* stocking bar while DJ sound checks, was calculated using the ISO 9612 formula, as shown in Figure 2.16;

$$u_{1a,m} = \sqrt{\frac{1}{I(I-1)}\left[\sum_{i=1}^{I}\left(L_{p,A,eqT,mi} - \bar{L}_{p,A,eq,m}\right)^2\right]}$$

Figure 2.16: Formula used to calculate standard uncertainty (ISO, 2009).

Where

$L_{p,A,eqT,mi}$ = The A-weighted equivalent continuous sound pressure level during a task of duration T_{mi}; (Value 1-3 from Step 4).

$\bar{L}_{p,A,eqT,m}$ = The arithmetic average calculated in Step 8.

i = The number of the task sample

I = The total number of task samples

In Excel the following formula was entered to carry out this calculation;

```
=SQRT(((1/(Task number-1)) * (POWER(Val1-Arith Avg,2)+(POWER(Val2-Arith Avg,2) + (POWER(Val3-Arith Avg,2))))
```

Step 10: The sensitivity co-efficients ($c_{1a,m}$) for uncertainty due to noise level sampling, instrumentation and measurement position were calculated using the ISO 9612 formula shown in Figure 2.17.

$$C1a,m = \frac{T_m}{T_0} 10^{0.1x\left(L^*_{p,A,eqT,m} - L_{EX,8h}\right)}$$

Figure 2.17: Calculation of sensitivity co-efficient for uncertainty (ISO, 2009).

Where

T_m = Estimated value of duration T_m for task m.

T_0 = The reference duration, *i.e.* an 8 hour working day.

$L^*_{p,A,eqT,m}$ = The A-weighted equivalent continuous sound pressure level for task *m i.e.* the result from step 5.

$L_{EX,8h}$ = daily A-weighted noise exposure level

In Excel the following formula was entered to carry out this calculation;

```
=(Len time/8)*(POWER(10,0.1*( Lp,AeqT - LEX,8h)))
```

Step 11: As shown in Figure 2.18, the combined standard uncertainty (*u*) was calculated using the ISO 9612 formula

$$u^2(L_{EX,8h}) = \left(\sum_{m=1}^{M} \left[c_{1a,m}^2 \left(u_{1a,m}^2 + u_{2,m}^2 + u_3^2 \right) + \left(c_{1b,m} u_{1b,m} \right)^2 \right] \right)$$

Figure 2.18: Calculation of the combined standard uncertainty for bartenders (ISO, 2009)

Where

$u_{1a,m}$ = The standard uncertainty due to the noise level sampling of the task (calculated in step 9).

$u_{1b,m}$ = The standard uncertainty due to the estimation of the duration of the task

$u_{2,m}$ = The standard uncertainty due to the instrument used for the task m. For a dosimeter this is a constant of 1.5 dB.

u_3 = The standard uncertainty due to the microphone position = a constant 1.0 dB.

$c_{1a,m}$ = The sensitivity co-efficient for task m based on noise measurements (calculated in step 10).

$c_{1b,m}$ = The sensitivity co-efficient for task m based on variability in task duration. This was excluded as there was no uncertainty over the task duration for each measurement.

m = The task number.

M = The total number of tasks.

In Excel the following formula was entered to carry out this calculation;

```
=(POWER(BV2,2)*((POWER(BU2,2)+(POWER(1.5,2)+(POWER(1,2))+((POWE
R(BV3,2))*((POWER(BU3,2))+(POWER(1.5,2))+(POWER(1,2)))+((POWER(BV4
,2))*(POWER(BU4,2))+(POWER(1.5,2))+(POWER(1,2))
```

Step 12: To calculate the expanded uncertainty (*U*) the ISO 9612 formula shown in Figure 2.19 was used.

$$U = 1.65 \times u$$

Figure 5.19: Formula used to calculate expanded uncertainty (U) (ISO, 2009)

As *u* was squared in step 11 the Excel calculation was

```
=1.65*SQRT(u^2)
```

2.3.8 Statistical analysis of all noise measurement data

All noise data was imported for statistical analysis. Independent T-tests were carried out to make comparisons between the nightclubs and discobars employees L_{Aeq}, L_{Cpeak}, $L_{EX,8h}$ and $\overline{L}_{EX,8h}$. Paired sample T-tests were conducted on dosimeter 1 and dosimeter 2 noise data to examine whether there were any significant differences between the 2 bartenders within venues. Differences between categorical data were analysed using chi-squared analysis *e.g.* if bartenders in nightclubs were required to wear hearing protection more often that bartenders working in discobars. ANOVA was used to explore whether there was a difference in L_{Aeq} levels in venues at 23:20, 00:15 and 01:00. Statistical significance was assumed at the $p < 0.05$ level.

2.4 Risk assessment-Noise risk characterisation and effects

This section of the methodology involved estimating the effect of noise on the health of the venue employees by both quantitative and qualitative means. As shown in Figure 2.20, the quantitative estimation of the effects of noise was carried out using the formulae from ISO 1999:1990.

A requirement of the Noise Regulations, 2007 was that employees are required to undergo screening hearing tests if noise levels exceed 80 dBA. Monitoring hearing screening provides a safeguard against the effects of noise induced hearing loss and monitors the effectiveness of procedures such as the wearing of hearing protectors (HSA, 2009). It was not possible to carry out audiometric testing on venue employees. An examination of the literature and consultation with a practicing audiologist established that a tinnitus history questionnaire could be reliably used to explore employees' experience of tinnitus.

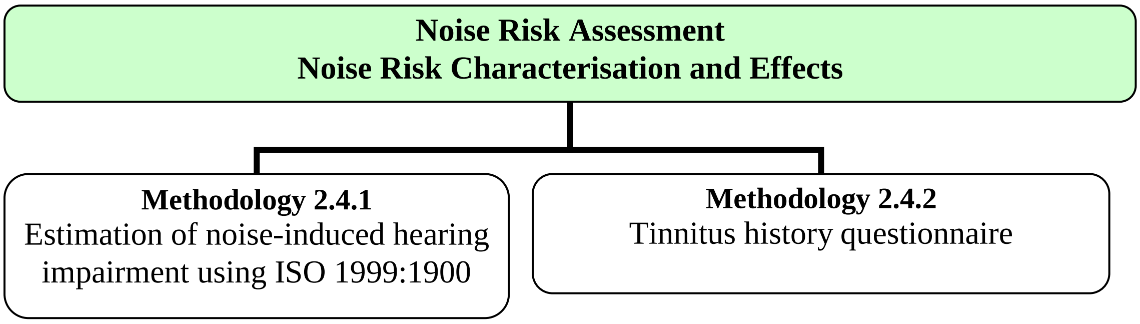


Figure 2.20: Noise Risk Assessment: Noise Risk Characterisation and Effects

2.4.1 Estimation of noise-induced hearing impairment

The bartenders daily noise exposure level calculated from Engineering $L_{EX,8h}$ dosimeter data were averaged in SPSS to create an arithmetic average Engineering $L_{EX,8h}$ noise exposure for nightclub and discobar bartenders. A similar methodology was used by Whitfield, in 1998, using mean $L_{EX,8h}$ for bartenders. In addition, the data collected on bartenders' age and years of experience working in the nightclub and discobar industry was averaged to give an exposure profile for the average bartender (see section 2.2.2).

In order to know what harmful effects noise can have on hearing it is essential to know what the hearing level of someone with no hearing exposure is at a given age (otologically normal person) as well as the hearing level of those who have been exposed to a certain noise level for a given number of years (noise exposed person). The effect of the noise is the difference between these 2 hearing levels. The formulae given in the ISO 7029:2000 standard documentation were applied to estimate the hearing threshold level associated with age (HTLA) for an otologically normal person. The noise induced permanent threshold shift (NIPTS) for people exposed to occupational noise was calculated using the formulae given in ISO 1999:1990. Next the risk of noise-induced hearing impairment was calculated for both the non-exposed population (H) and the noise-exposed population (N). The hearing threshold level associated with age and noise (HTLAN) was calculated by adding H + N. Finally the resulting relationship between H and HTLAN' was then plotted on Gaussian co-ordinates with the risks of hearing disability illustrated for an arbitrary "fence" of 27 dB. The dependence of the risk values on the magnitude of the fence were studied with the plot (ISO, 1990).

2.4.2 Tinnitus history questionnaire

All venue employees who completed the noise questionnaire also completed a 14 question tinnitus history questionnaire. The questions were based on validated questions used by General Practitioners and audiologists (Bray *et al.*, 2004; Lee, 1999. For a copy of the tinnitus history questionnaire please refer to Appendix 4.

2.4.3 Analysis of Noise Risk Characterisation and Effects

The mean and worst-case HTLAN figures for bartenders of both genders were entered into SPSS. Independent T-tests were carried out to determine whether there was any significant difference between the HTLAN of males and females and also whether there was a significant difference between the HTLAN of bartenders in nightclubs and discobars. Statistical significance was assumed at the $p < 0.05$ level.

The employees' responses to the tinnitus history questionnaires were entered into SPSS. The categorical data was then analysed using chi-squared analysis to examine any statistical differences between the employees. Statistical significance was assumed at the $p < 0.05$ level.

2.5 Chapter summary

The aim of this chapter was to describe the methods used to conduct an exploratory noise risk assessment of occupational noise exposure. Three approaches associated with noise risk assessments were adopted; noise hazard identification, noise hazard characterisation and noise risk characterisation.

Noise hazard identification

Eighteen venue managers participated in interviews and questionnaires were completed by 80 employees to establish noise exposure patterns for noise hazard identification.

Noise hazard characterisation

Noise hazard characterisation involved the use of dosimeters and two Sound Level Meters to accurately estimate the daily and weekly noise exposure of employees. A control group of ten venues was used to account for the noise levels in venues when management and staff were not aware that noise measurements were taking place.

Noise risk characterisation

The calculation of bartenders' noise exposure using the Engineering $L_{EX,8h}$ method was deemed necessary to estimate the long-term risk of hearing impairment using ISO 1999:1990. A tinnitus history questionnaire was used to explore employees' experience of tinnitus.

Chapter 5 of this thesis will present the noise risk assessment data and observations as applied to twenty nightclub and discobar venues.

Chapter 3

METHODOLOGY

Noise Risk Management

3.0 Introduction

Noise is often a by-product of heavy industry but, in the entertainment industry, noise is often the desired effect. Hence, the challenge is to protect employees where loud music is played, while still delivering the desired experience (Reid, 2005). The overall aim of this section of the methodology was to explore ways to reduce the risks indentified by the noise risk assessment described in Chapter 2.

There were 3 distinct objectives:

1. Determine level of compliance with the Noise Regulations, 2007 and adherence to the HSA guidance document "Noise of Music".
2. Explore the challenges faced by authorities when enforcing the requirements of the occupational noise legislation.
3. Select suitable hearing protection for the venue employees.

The Noise Regulations, 2007, stipulate that at the lower (80 dBA) and upper exposure (85 dBA) action values certain control measures must be put in place.

3.1 Risk management – Noise control options available

Risk management is policy based and concerned with legal and administrative controls of risks (Royal Society, 1992). As shown in Figure 3.1 the methodology used questionnaires and physical observations to gain knowledge of the control measures in venues. The challenges faced in enforcing the occupational noise legislation were explored using an online questionnaire, completed by enforcement officers in Northern Ireland (NI).

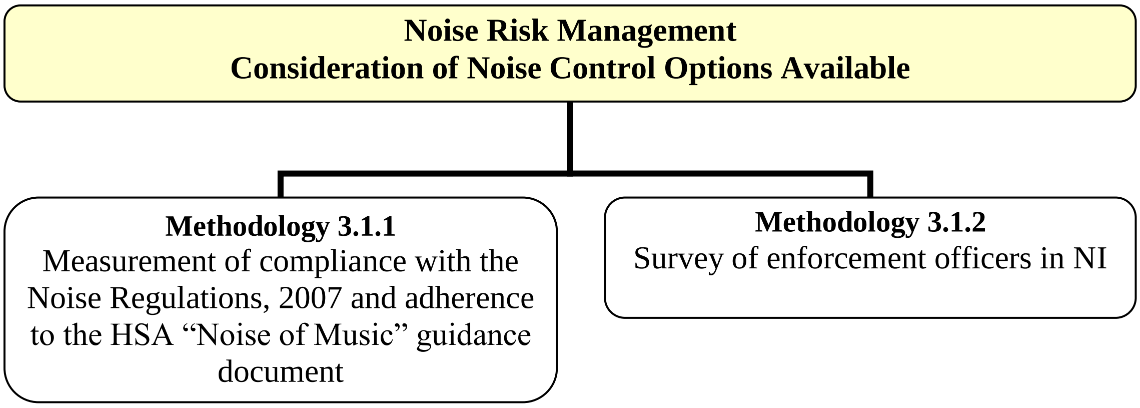


Figure 3.1: Noise Risk Management: Consideration of Control Options Available

3.1.1 Measurement of compliance with Noise Regulations, 2007 and adherence to the HSA guidance document "Noise of Music"

A compliance assessment for each venue was performed based on the legal requirements of the Noise Regulations, 2007 and the recommendations outlined in the HSA "Noise of Music" guidance document.

3.1.1.1 Data collection via manager questionnaire

The management questionnaire, previously described in Chapter 2, section 2.2.1, was used to ask about noise management practices in each venue *e.g.* whether there was a safety statement or noise risk assessment. Additionally the questionnaire was used to establish:

1. Whether employees were provided with hearing protection?
2. Were those in control of noise levels instructed on how to use the audio equipment correctly?
3. Were employees trained in relation to noise induced hearing loss?
4. Was audiometric testing available to employees?

The management interviews were designed to explore knowledge of the requirements of the Noise Regulations, 2007 and recommendations outlined in the HSA "Noise of Music" guidance document. For a copy of the venue manager questionnaire please refer to Appendix 3.

3.1.1.2 Observation of venue design features

A checklist was designed to record the venues design features, based on guidelines in the HSA document "Noise of Music". The venues were inspected, prior to opening to the public, to determine the following:

1. Layout of the venue, location of bars and dance-floor(s).
2. The distance between dance-floor and bar, measured using a digital laser measuring tape (Leica Disto Lite).
3. Number of loudspeakers, orientation and location in the venue.
4. Were screens/glass barriers used to isolate the noise source from bartenders?
5. Was suitable hearing protection and signage in place?
6. Was hearing protection worn by venue employees and was it worn correctly?

3.1.1.3 Estimation of a compliance for venues

Data from the calculations of task $L_{EX,8h}$ for all employees, along with the details collected in the manager noise questionnaire and venue physical inspections were gathered together under 6 main headings:

1. Noise survey.
2. Noise control measures.
3. Training and instruction.
4. Audiometric testing.
5. Personal hearing protection.
6. Noise management.

This approach was based on a compliance assessment conducted by Lutman, Davis and Ferguson in 2008 in 19 companies (not including nightclubs). Each item in each heading was categorised using a 3-point scale:

0 = not met. 1 = partially met. 2 = fully or almost fully met.

Each of these values was then multiplied by a weight for each item (established by Lutman, Davis and Ferguson, 2008). All headings were then sub-totalled, added together and a compliance percentage was established for each venue related to the Noise Regulations, 2007 and the HSA “Noise of Music” guidance document. Please refer to Appendix 6 for the tables related to weightings of items under each of the 6 headings.

Note: The score for the heading “Noise control measures” was assessed based on the specific *noise control* measures recommended in the HSA “Noise of music” guidance document. At the top of the HSAs hierarchy of control measures was the requirement to eliminate the hazard. Where prevention of a risk is not possible, the next option is to control the risk. The HSA recommend reducing the music volume or suspending loudspeakers to increase their distance from employees as a noise control measure.

3.1.2 Measuring enforcement officers opinion of noise risk management

To identify the challenges faced by officers in enforcing the occupational noise regulations, a 10-item questionnaire was designed, compiled and made available using internet software, Survey Monkey (for a copy of the enforcement officers questionnaire please refer to Appendix 7). The enforcement officers’ questionnaires were designed based on and adapted from the requirements of the Noise Regulations, 2007, recommendations outlined in the HSA “Noise of Music” guidance document and the compliance assessment conducted by Lutman, Davis and Ferguson (2008). Pilot testing was conducted on three enforcement officers to ensure face validity of the open ended and close ended questions.

The researcher had previously delivered a noise training session to the NI Environmental Health Officers (EHOs) in November 2010. As a result, contact was made with the Chief Environmental Health Officers Group (CEHOG) in NI who agreed to participate in the enforcement officers' questionnaire. The legislative occupational noise requirements were identical in both NI and the Republic of Ireland.

3.1.2.1 Distribution of the enforcement officers' questionnaire.

The CEHOG made available a list of delegates who attended noise training in 2010. In total 60 EHOs were emailed explaining the research and requesting completion of the enforcers' questionnaire. A link in the email brought the EHO to the Survey Monkey questionnaire online which was live from 6th August to 20^{th} August 2012.

3.1.2.2 Analysis of the enforcement officers' questionnaire

The Survey Monkey software automatically gathered the enforcement officers' responses online. Once the questionnaire was closed on 20^{th} August, the findings were summarised to gain an insight into the enforcements officers' opinions.

3.2 Risk management – Selection and implementation of noise controls

The Noise Regulations, 2007 required employees to wear hearing protection when their noise exposure exceeded 85 dBA. This section of the methodology details the method used to select suitable hearing protection for all venues (as illustrated in Figure 3.2).

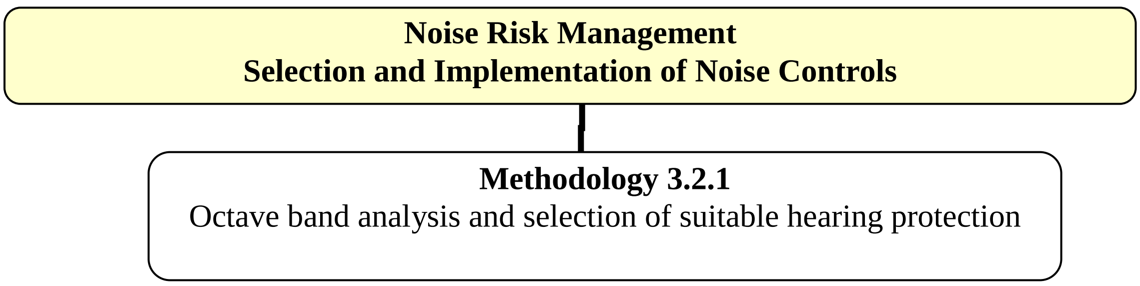


Figure 3.2: Noise Risk Management: Selection and Implementation of Controls

3.2.1 Selection of suitable hearing protection using octave band analysis data

When selecting suitable hearing protection the characteristics of the noise measured *e.g.* sound pressure level and frequency content must be known. The method used to collect noise exposure data was previously described in Chapter 2, section 2.3.3. ***Note***: The average noise level (L_{Aeq}) measured by an SLM did not give the breakdown of sound in the low, mid and high frequency range. The 2238 Mediator SLM was modified by addition of software for octave band analysis. The additional software (Frequency Analysis Software BZ 7123) provided information across the 8 centre frequency bandwidths (1/1 octave bands).

3.2.1.1 Calculation of suitable hearing protection using British Standard 458:2004

The method used to select suitable hearing protection was based on the venue octave band analysis results for each nights measurements and the formulae in British Standard (BS) 458:2004 – hearing protectors, recommendations for selection, use, care and maintenance. To select suitable hearing protection the octave band method was used.

The first step involved calculating the A-weighted sound pressure level (L'_A) when using the hearing protector. This was achieved using the calculation shown in Figure 3.3:

$$L'_A = 10\log\sum_{f=63}^{8000} 10^{0.1(A_f - APV_f)}$$

Figure 3.3: Formula used to calculate the A-weighted sound pressure level when using hearing protection (BS, 2004).

Where:

f represented the centre frequency of the octave band in Hz; the worst-case scenario octave band frequencies measured in each venue *i.e.* at 01:00 was used for f.

A_f was the frequency weighting A in dB for octave band centre frequency f;

APV_f was the assumed protection value of the hearing protector in dB.

The L'_A was rounded to the nearest integer *e.g.* the A-weighted sound pressure level under the hearing protector was 81 dBA. This result was then compared to the result in Table 3.1. This was carried out for 5 different types of hearing protection supplied in Ireland for each venue.

Table 3.1: Assessment of the sound attenuation of a hearing protector

Level Effective to the Ear (L'_A in dB)	**Irish legal limit**	**Protection Rating**
Greater than L_{act}	> 85 dBA	Insufficient
Between L_{act} and L_{act} -5	85-80 dBA	Acceptable
Between L_{act} -5 and L_{act} -10	80 - 75 dBA	Good
Between L_{act} -10 and L_{act} -15	75 – 70 dBA	Acceptable
Less than L_{act} -15	< 70 dBA	Too high (Overprotection)

Note: L_{act} was the nationally defined upper Exposure Action Level *i.e.* In Ireland this was 85 dBA (Adapted from BS 458:2004).

3.2.1.2 Statistical analysis of hearing protection data

An independent sample T-test was conducted to evaluate whether there was a significant difference between A-weighted sound pressure level (L'_A) provided by the earplugs in nightclub and discobar venues. In all cases, a significant difference was noted if p was < 0.05.

3.3 Chapter summary

Due to transposition of the EU Directive 2003/10/EC into Irish Law, the entertainment sector was obliged to comply with the requirements of the Noise Regulations, 2007 since February 2008. Despite this, there was a lack of baseline data on the adoption and appreciation of these regulations within the sector. The aim of this chapter was to explore the noise risk management options available to reduce the risks indentified by the noise risk assessment described in Chapter 2.

Manager questionnaires and physical observations were used to gain knowledge of the control measures in venues. A noise compliance assessment was conducted based on an approach described by Lutman, Davis and Ferguson (2008). The challenges faced in enforcing the occupational noise legislation were explored using an online questionnaire, completed by enforcement officers in Northern Ireland (NI).

Noise is often a by-product of heavy industry but, in the entertainment industry, noise is often the desired effect. Hence, the challenge is to protect employees where loud music is played and to be in compliance with the Noise Regulations, 2007 while still delivering the desired experience for patrons (Reid, 2005). The final noise risk management approach outlined in this chapter was the selection of suitable hearing protection for all 20 venues by using the octave band analysis data from Chapter 2 and the formulae from; British Standard (BS) 458:2004 – hearing protectors, recommendations for selection, use, care and maintenance.

Chapter 6 of this thesis will present the noise risk management observations as applied to twenty nightclub and discobar venues and the data generated from the EHO questionnaires.

Chapter 4

METHODOLOGY

Noise Risk Communication

4.0 Introduction

This aspect of the risk analysis model explored noise risk communication in the nightclub/discobar industry. Risk communication is a process whereby risks to health are communicated in a responsible and effective manner (Lum and Tinker, 1994). In the beginning of a risk communication process, it is assumed that the public are deficient in their knowledge relating to a risk and that the ultimate goal is to rectify the "knowledge gap" (Frewer, 2003).

The overall goal of the noise risk communication aspect of this study was to develop a noise awareness training programme and to conduct a pilot study to assess the effectiveness of such training. The objective of such training was to improve employee noise awareness knowledge, increase the use of hearing protection devices in their workplace and assess the safety culture in the participating venues.

4.0.1 Outline of risk communication methodology chapter

In the past, occupational safety interventions have been criticised for not seeking sufficient evidence of the effectiveness of interventions (Goldenhar and Schulte, 1994; Shannon, Robson and Guastello, 1999). The noise risk communication methodology described was guided by incorporating the recommendations for occupational safety interventions suggested by Shannon, Robson and Guastello, 1999.

Figure 4.1 shows the merging of the recommended stages of the intervention framework and the stages of noise risk communication. This results chapter is presented in 6 sections, as per Figure 4.1. These are: risk communication intervention objectives, interactive exchange of information and objectives, development of noise training intervention, implementation of noise training intervention, measurement of immediate intervention outcome and measurement of intermediate intervention outcome.

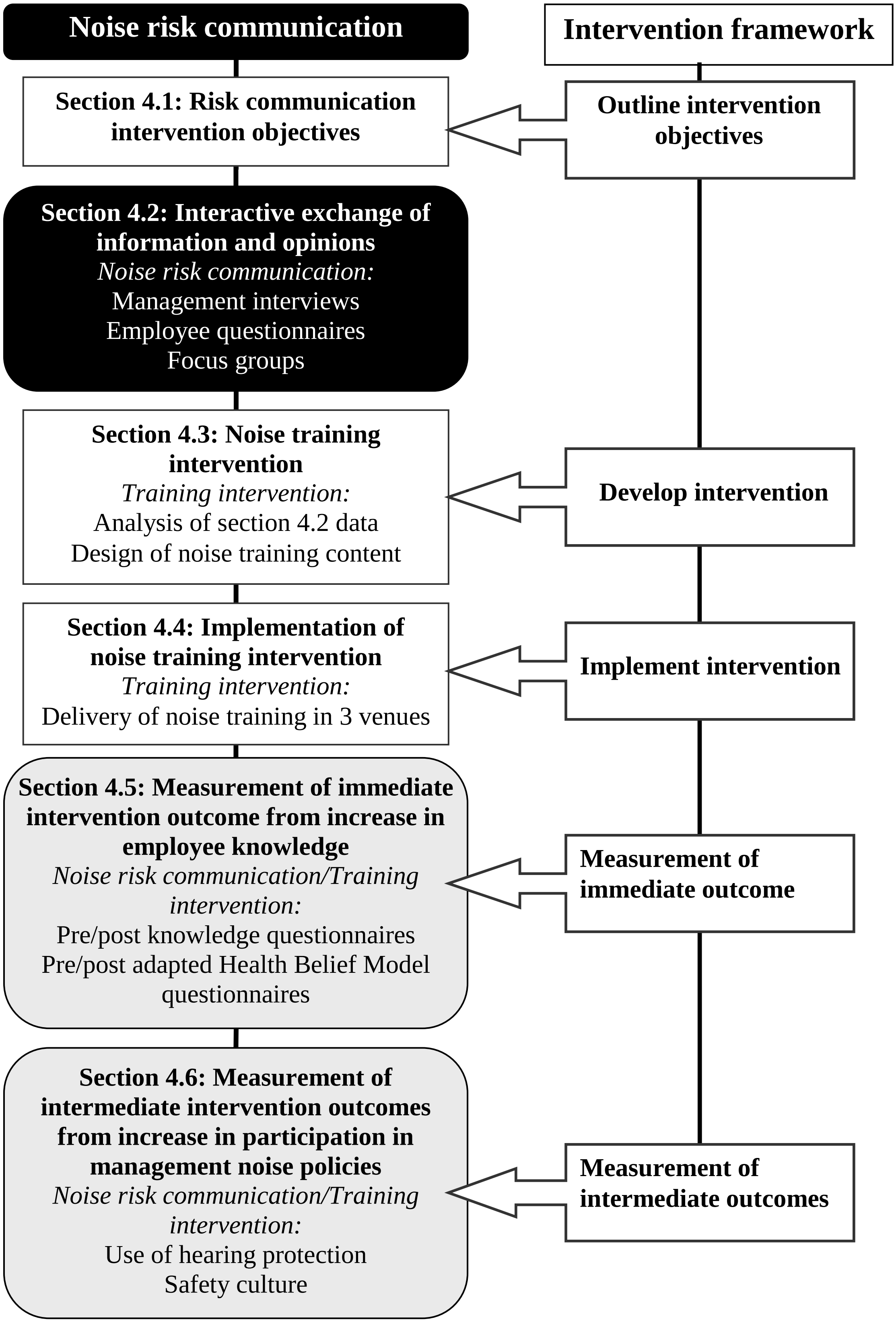


Figure 4.1: Merging of the recommended stages of the intervention framework (white boxes) and the stages of noise risk communication (black box). The grey boxes

represent the merging of the intervention framework with the stages of noise risk communication.

4.1 Risk communication intervention objectives

As illustrated in Figure 4.1, the first step of the intervention was to identify noise risk communication objectives:

1. Develop an effective noise awareness training programme that will target employee beliefs and barriers. This objective was broken into 3 areas to:
    a. Establish whether noise awareness training enhanced the participants knowledge of the legislation and the effects of noise on health.
    b. Measure whether noise awareness training significantly affected the participants' attitudes as assessed by the adapted Health Belief Model (HBM) constructs (see section 4.2.3.1 for further details).
    c. Explore whether the noise awareness training significantly influenced the wearing of hearing protection by employees in their workplaces.
2. Investigate the safety culture in venues and the reasons for non-compliance to the Noise Regulations, 2007.

4.2 Interactive exchange of information and opinions

Formative research must identify the attitudes, beliefs and behaviours of the target audiences in relation to risk (Patel *et al.,* 2001). For noise risk communication this involved the measurement of employer and employee knowledge of the Noise Regulations, 2007 requirements and their attitudes towards the noise. This was achieved through the use of a face-to-face interview with managers and by the use of questionnaires for employees.

The close ended questions in the noise questionnaire for venue employees showed that employees were reluctant to wear hearing protection at work, even if provided by management. Since no previous studies had examined the use of hearing protection by staff, the use of focus groups was employed as formative research to investigate the opinions and experiences of venue employees and to explore their perception of barriers to hearing protection use.

4.2.1 Structured noise interview with venue managers

A 35 question interview was designed, compiled and conducted with venue managers. The questions related to compliance and venue design were previously outlined in section 2.2.1. The noise interview for managers was used to gather demographic information on the manager including his/her qualifications. Nine questions were used to measure their knowledge of their legislative responsibilities. Fourteen questions were used to assess their attitude to noise (please refer to Appendix 3).

4.2.2 Venue employee noise questionnaire

At the beginning of each noise monitoring visit prior to the venue opening to patrons, all employees were approached. An outline of the research project was described to the employees and they were invited to complete the noise questionnaire. Completion of the questionnaire took approximately 15 minutes.

The questionnaire measured employees' knowledge of the specific requirements of the Noise Regulations, 2007. Five questions assessed their attitudes to noise in venues and to wearing hearing protection. Eight questions examined the employees' experience of noise in their workplace (please refer to Appendix 4).

4.2.2.1 Statistical analysis of manager and employee questionnaire data

The responses from the interview and questionnaire data were used to identify manager and employee knowledge gaps related to noise exposure. The responses were used for the initial stages of development of the focus group methodology.

4.2.3 Focus group methodology

Focus groups have been used in public health research to collect qualitative data on participants' opinions and behaviours (Lombardi, 2009). The focus group findings were used to develop a pilot study noise awareness training content.

4.2.3.1 Design of the focus group discussion guide

The focus group discussion guide was developed to include questions that encompassed the theoretical constructs of the Health Belief Model (HBM) and Health Promotion Model (HPM) combined (hereinafter adapted HBM). The questions were designed based on the questions used in focus groups related to hearing protection use in different industries (Stephenson and Stephenson, 2011; Tantranont *et al.,* 2009; Abel, 2008; Prince *et al.,* 2004; Patel *et al.,* 2001). Pilot testing was conducted on 3 nightclub employees to ensure face validity of the open ended and close ended questions.

Table 4.1 lists the 4 areas covered by the focus group discussion guide and the adapted HBM construct that was used in the discussion (see Chapter 1, section 1.15.2 outlining the HBM and HPM).

Table 4.1: Focus group discussion guide layout based on adapted HBM constructs

	Focus group topic	Adapted HBM construct(s) covered in questions
1	Employees experience of noise in their workplace.	Perceived susceptibility of hearing loss risk. Perceived severity of hearing loss risk
2	Opinions and barriers to use of hearing protection	Perceived barriers and benefits to taking action against the hearing loss risk.
3	Management commitment to noise control and its management	Interpersonal influences from co-workers and the social norms in the workplace. Situational influences related to the safety climate in the workplace. Self efficacy *i.e.* the belief in ones ability to effectively control a risk.
4	Recommendations for noise awareness training.	All of the adapted HBM constructs above.

Please refer to Appendix 8 for the full discussion guide generated for focus groups.

4.2.3.2 Recruitment of participants

Each of the 20 venues where noise monitoring was conducted during the research (Chapter 2) was invited to participate in the focus group element of the study. When the noise risk assessments were posted to the venue, each manager was invited to participate in the focus groups. Three venues agreed to participate in the research. In general there are no more than 2-5 focus groups conducted in social science studies (Krueger and Casey, 2009). In line with recommendations from Castel *et al.,* 2008, 2 groups from each venue were chosen to limit the level of bias that may be seen from a single group and to allow the examination of common themes between groups.

The 3 venues differed in relation to the provision of hearing protection to employees:

- Club A = hearing protection had only been made available 2 months prior to the focus group sessions in July 2011.
- Club D = no hearing protection was made available to employees prior to the focus group session in September 2011.
- Club I = hearing protection was a mandatory requirement for all employees to wear since the opening of the nightclub venue in 2006. The focus group session was held in October 2011.

A sample of participants was obtained by placing a poster in the staff area in each of the participating venues calling for enrolment in the focus groups. Two separate days were offered in each venue to increase attendance. No more than 10 participants per group were scheduled. The only criterion set for the participants was that they were to be employees currently working in the venue.

4.2.3.3 Focus group sessions

Each focus group lasted approximately 2 hours with a 10-minute break in the middle of the session. Snacks and refreshments were provided. The focus groups were conducted outside of venue operating hours. Sessions were audio taped using a digital stereo H2 Zoom recorder with build in 360 degree microphone. The seating arrangement in each of the groups was in the form of a circle where each person was an equal distance from the recording microphone as per Figure 4.2 below.

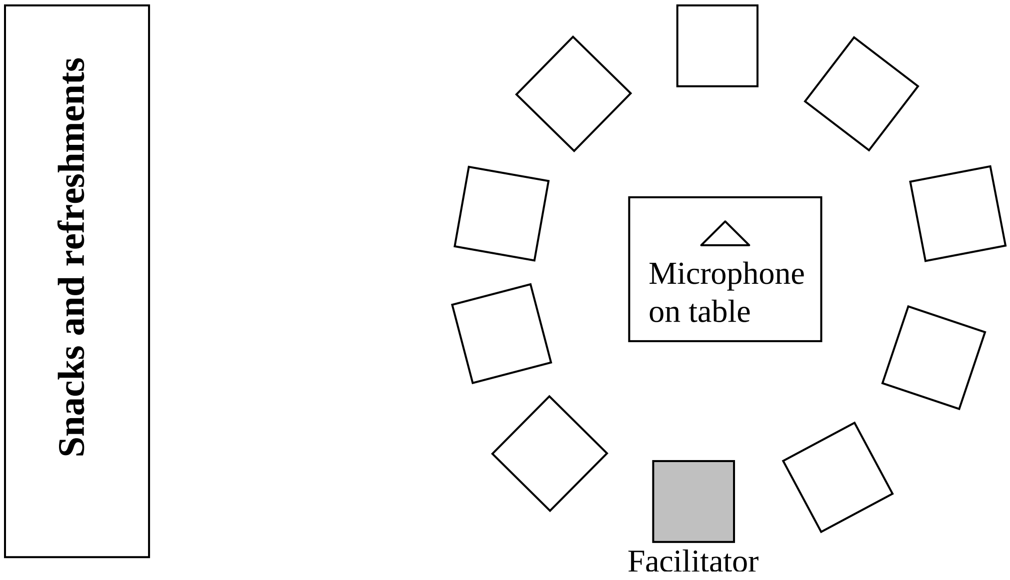


Figure 4.2: Illustration of focus group seating layout

Participants were told that the details gathered in the focus groups would not be shared with their management. This encouraged them to speak truthfully of their experiences and attitudes their issues with noise exposure and use of hearing protection.

An introduction to the research project was delivered to the participants. A consent form (Appendix 9) was handed out to each participant and read aloud by the facilitator. Time was allotted for questions.

The expression of opinions was encouraged and participants were instructed that there were no wrong answers to any questions asked. The goal was to create a safe environment, where all employees were invited to share their opinions.

The session commenced with an ice-breaker and general questions. Topics were initially presented as open ended questions. The facilitator probed and guided the discussion with follow up questions under each theme until each question had been exhaustively addressed. The richness of data generated from focus groups relied on participants feeling comfortable about communicating their opinions and experiences openly (Stewart *et al.,* 2007). The facilitator aimed to conduct the focus groups efficiently allowing each person equal "talk time" and preventing unnecessary interruption. This promoted respect and the voluntary sharing of opinions and experiences related to the 4 noise topics, as previously referred to in Table 4.1 (see section 4.2.3.1).

4.2.3.4 Demographics form

A self-administered anonymous questionnaire was used to collect the employees' demographics, work history and information on their work role. The questionnaire was completed at the beginning of the second half of the focus group sessions after a 10-minute break (See Appendix 10).

4.3 Noise training intervention

Noise training was identified as a legal requirement under the Noise Regulations, 2007. Improving employee knowledge of a risk does not always translate into improved behaviour (Cohen *et al.,* 2001). Noise awareness training was designed to address the criteria identified in the legislation: it was developed using knowledge gained from the manager interviews, employees' questionnaires and focus groups. Employee education and motivational training have previously been successful at increasing hearing protection usage (Sergio and Miguel, 1996).

4.3.1 Data analysis of focus groups

Audiotapes were transcribed verbatim. The transcripts were reviewed for emerging themes. At the end of the fifth focus group it was felt that no new or emerging themes had arisen and the process was ended.

The electronic transcriptions were sorted, using NVivo (Version 9 a qualitative analysis software programme), into responses to each individual question, followed by quotes from focus group participants. Similar quotes were grouped together into a file (nodes) (based on the adapted HBM constructs) to identify themes. Each adapted HBM node was addressed in the training program.

4.3.2 Development of training intervention content

The noise awareness training curriculum was designed to raise employee awareness of the noise hazards in their workplace and encourage them to wear hearing protection. All of the adapted HBM constructs were represented in the training as shown in Table 4.2 overleaf.

Table 4.2: Adapted HBM constructs related to training section and method used to address the construct

Adapted HBM construct	Training section	Method/Media used
Perceived susceptibility	Examples of noise exposures from both occupational and everyday sources.	**Group discussion:** Opinions on sound levels. **PowerPoint:** Noise thermometer slide.
	Employee exposure to noise in their workplace.	**PowerPoint:** Daily noise exposure based on job title. **Group discussion:** Reactions to the noise levels.
Perceived severity	Noise and its effects on hearing.	**Video:** Health and Safety Executive (HSE) UK 3-minute video on how the ear works and why it is at risk from noise. **PowerPoint:** Three pictures of hair cell damage from noise exposure.
	Simulated effects of hearing loss.	**Group discussion:** “What does being able to hear mean to you?” **Audio:** Simulation of hearing loss and its effects from HSE UK website and a one minute video of ringing similar to tinnitus.
	Self administered hearing test	**Internet based hearing test:** Carried out individually over 5-minutes.
Barriers/Benefits of hearing protection use	Discussion of common barriers to use of hearing protection.	**Group discussion:** Topics identified during focus groups addressed and discussed with the participants.

Table 4.2 (Continued): Adapted HBM constructs related to training section and method used to address the construct

Adapted HBM construct	Training section	Method/Media used
Barriers/Benefits of hearing protection use	Practical demonstration of when and how to use hearing protection.	**Paired role play:** Music played while wearing hearing protection, information from cards read aloud and noted by partner. **Group discussion:** Related experience of comfort and fit of earplugs.
Self-efficacy	Improving the insertion of hearing protection.	**Paired demonstration:** Introduction and demonstration of two earplug types chosen to protect from the noise levels in the entertainment venue.
Interpersonal influences	Challenges faced by the industry	**Group discussion:** Open discussion of the challenges faced by the industry to become compliant with the Noise Regulations, 2007.
Situational influences	The measurement of noise and the requirements of the Noise Regulations, 2007.	**PowerPoint:** Illustration of the equal energy principle and requirements of the Noise Regulations, 2007.
	Actions taken by management to reduce the risk of hearing loss to employees.	**Group discussion:** Open discussion of the actions taken by management to reduce noise exposure in the venue.

The training session was designed to last for 2 hours and cover the areas highlighted in Table 4.2. During training the 6 adapted HBM model constructs were addressed multiple times during the training session using venue specific examples and statements gathered from the noise risk assessment and noise risk management elements of the research. Towards the end of the training the employees were invited to discuss their opinions. This time was also used to take participants' questions.

4.4 Implementation of pilot noise training intervention

A quasi experimental non-randomised design was used where venues were assigned into an intervention group (training delivered) or a control group (no training delivered). The following section outlines the steps taken to deliver training intervention to the participating venues, as per Figure 4.3 below.

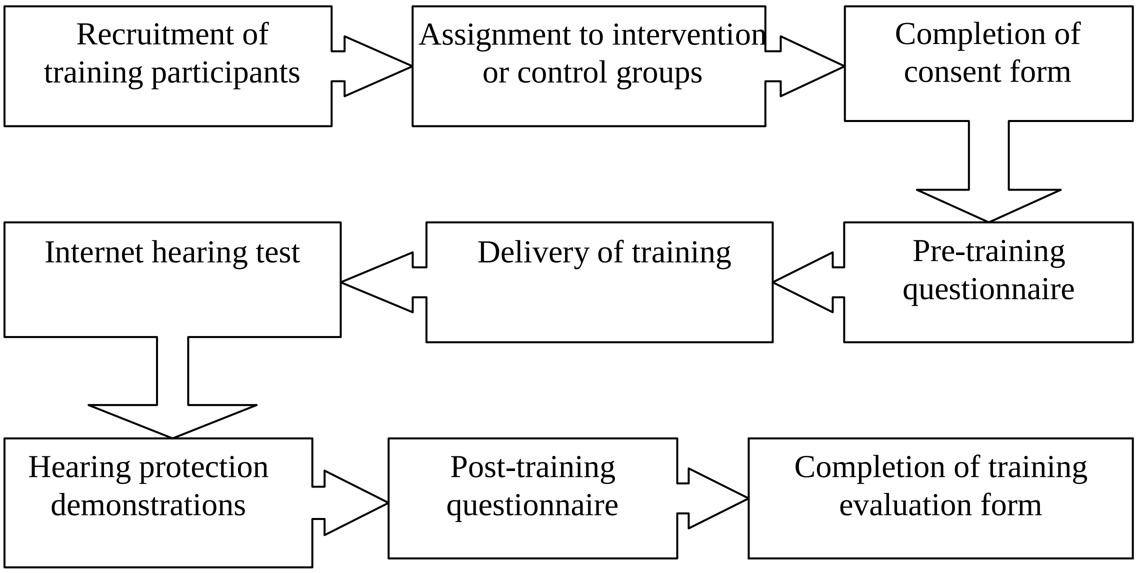


Figure 4.3: Flowchart for delivery of noise awareness training intervention

4.4.1 Recruitment of pilot noise awareness training participants

Most of the venue managers who were involved in the noise risk assessment (Chapter 2) were not interested in participating in the training intervention. However, 3 venues, Club A, Club I and DB 5 did participate in the training intervention. The management were asked to involve all employees in the training; bartenders, glass collectors, security personnel and cloakroom/cash desk staff. DJs were not included in the training.

4.4.1.1 Workplace characteristics

Club A was located in a town in Leinster and consisted of 7 full-time and 33 part-time employees. The nightclub was open 4 nights a week and employees were exposed to a task $L_{EX, 8h}$ between 70-103 dBA. The venue had been awarded a "Nightsafe" award by the Irish Nightclub Industry Association (INIA). Hearing protection was made available but its use was not enforced by the management. No noise training was delivered to the employees, consequently the participants in this venue were used as a control group to measure changes in knowledge, adapted HBM constructs and safety culture without training intervention.

Club I was located in a town in Leinster and the nightclub was open 5 nights per week. There were 4 full-time and 27 part-time employees who were exposed to a task $L_{EX, 8h}$ between 70-94 dBA. The managers in the venue were in the process of assembling the documents required for the "Nightsafe" audit by the INIA. Hearing protection was mandatory for all employees. Management enforced the use of hearing protection during the employees' work-shift.

DB 5 was located in Dublin city centre and consisted of 35 full-time and 30 part-time employees. It was open 7 days per week: on 4 nights it was open until 02:30. Employees were separated into daytime and night-time staff. Only those employees who were exposed to increased noise levels from 21:00 onwards were included in the training intervention. The late night employees were exposed to a task $L_{EX,\ 8h}$ between 71-94 dBA. The management had never made hearing protection available prior to the training intervention or sought the "Nightsafe" award.

4.4.2 Assignment of intervention and control groups

A 2 group comparison study with non-randomised assignment was used due to the limited number of venues participating in the intervention. The participants were assigned into intervention group or control group. If the control group consisted of employees from the same venue there could be a contamination of the control group *i.e.* the control group are influenced by their co-workers wearing hearing protection or the sharing of information from the noise awareness training (Shannon, Robson and Guastello, 1999). All of the venues were located in different towns and had no relationships to the other participating venues.

4.4.3 The training intervention consent form

An informed consent form was provided for the noise awareness training participants to read and complete before participating in the training. The consent form was signed by all noise awareness training participants before participating in the training (see Appendix 11).

4.4.4 Pre-training questionnaire

The participants all completed a pre-training questionnaire which was separated into 3 sections: demographics, knowledge of legislation and attitude to aspects of HBM constructs (see Appendix 12). The pre-training questionnaires were designed based on the questions used in previous noise awareness training intervention studies by Stephenson and Stephenson, 2011; Edelson *et al.,* (2009); Neitzel *et al.,* (2008);McCullagh, Lusk and Ronis, (2002). Pilot testing was conducted with 3 nightclub employees to ensure face validity of the open ended and close ended questions.

4.4.5 Noise awareness training delivery

Participants in the intervention group completed the consent form, pre-test, training programme, post-test course evaluation and retesting 6 to 8 weeks after the training programme. The control group completed the consent form and pre-test but were omitted from the training. Finally they completed the post-test and retesting 6 to 8 weeks later. Training was held on-site outside operating hours. The training was kept as informal as possible with the instructor encouraging questions and discussion from the participants. To ensure training was engaging, videos, audio clips, demonstrations of hearing protection and its fit, were used to illustrate non-occupational and occupational noise levels (see section 4.3.2, Table 4.2 for details of the training content).

4.4.5.1 Internet hearing test

An informal internet based hearing test was used to raise the participants' awareness of the effects of noise. Two laptops were set up in a quiet space. While the trainer was demonstrating the hearing protection to 2 participants, the other trainees were invited to take an online hearing test wearing personal noise cancelling headphones (Sennheiser HD201). The hearing test was available from www.hear-the-world.com/en/recognize-hearing-loss/online-hearing-test.html.

4.4.5.2 Practical demonstrations

The first demonstration involved the trainer demonstrating the correct insertion techniques required with 2 different types of hearing protection *e.g.* a soft disposable earplug and a direct insertion reusable earplug. The following script was adopted from that used in Murphy *et al.*, 2011 for the Howard Leight earplug study:

1. Before inserting the hearing protection, cup hands over the ears and speak aloud. Notice how the voice sounds differently when you repeatedly uncover and cover the ears.
2. Participants shown how to roll the earplugs ensuring they are crease free.
3. Reach over the head and pull the ear back and up to straighten the ear canal.
4. Stop inserting when you can feel your finger touching your ear.
5. Hold the earplug in place for a few seconds while it expands.
6. Checking for a good fit is carried out using a voice check by covering the ears again and speaking out loud. Notice how your voice does not seem to change as you repeatedly uncover and recover the ears. If there is very little change then the earplugs are correctly inserted (Murphy *et al.*, 2011).
7. Each participant was then observed inserting the different types of hearing protection and was corrected in their technique as necessary.

Directions were given for a pre-moulded or direct insertion earplug in pairs of participants over a 5 minute period.

The second demonstration involved turning on the music to the level experienced on a Saturday night. This was checked using a sound level meter (SLM) measurement recorded at head height in the area where participants were trained. All participants were instructed to insert their choice of hearing protection. A card was handed out to each participant to read to their partner across the bar *i.e.* approximately arms length. This was to replicate the work environment. In order to eliminate lip-reading the statements on the cards were related to the noise awareness training. Once this exercise was complete the music was turned off and participants were asked to share their experiences. This practical demonstration was used to address the employees' barriers to hearing protection use and allow them to improve their self efficacy using hearing protection without the pressure of actually having to serve customers.

4.4.5.3 Following noise awareness training delivery

After each training session, participants were asked to complete a post-questionnaire based on the adapted HBM constructs. Responses were coded, based on the 5-point Likert scale used and statistically analysed (see section 4.5.2.2 for further analysis details).

4.3.5.4 The training evaluation form

An anonymous evaluation form was distributed to the participants immediately following the post-test questionnaire (Hughson, Mulholland and Cowie, 2002). The form was used to elicit the participants' opinions of the usefulness of the noise training. Multiple choice questions measured satisfaction with the training delivery based on the questions previously used by Hughson, Mulholland and Cowie, (2002) (see Appendix 13 for a copy of the noise training evaluation form).

4.5 Measurement of immediate intervention outcome

The immediate effect of the training intervention was assessed by comparing the change in the outcome variable (knowledge) before and after the intervention to that of the control group.

4.5.1 Procedure to measure knowledge changes

Training and control group participants both completed questionnaires on 3 occasions: at the commencement of the training intervention, directly after the training intervention and 6 to 8 weeks after the commencement of the training intervention. Immediately after completing the first set of questionnaires, the training group participants participated in a voluntary training session for 2 hours conducted by the researcher. The control group completed the questionnaires but did not participate in the training session.

All noise awareness training participants were tested on their knowledge of the sources of noise in their lives, effects of excessive noise, noise related legislative requirements and suitable control measures to reduce noise exposure in their workplace (see Appendix 12).

4.5.1.1 Knowledge data analysis

Descriptive statistics were used for the demographic data (except for name) in order to identify any differences between the intervention and control groups or between venues. The answers to the knowledge questions were coded correct or incorrect. In each case, “Don’t Know” or “No response” was scored as incorrect. The total number of correct responses was tallied using the “Transform” function in SPSS.

Paired t-tests (pre/post knowledge, pre/revisited knowledge and post/revisited knowledge scores) were computed for each participant. A significant difference was noted before and after the intervention if $p < 0.05$.

4.5.2 Procedure to measure Health Belief Model attitude changes

All pre, post and revisited training intervention questionnaires had survey items designed to assess whether the employees improved their attitudes based on the adapted HBM constructs. Previous studies have used a similar approach (Stephenson *et al.*, 2011; Edelson *et al,* 2009).

4.5.2.1 Manipulation and analysis of HBM survey data

The 20 adapted HBM survey items were completed by all intervention and control groups. The data was entered into SPSS based on the 5-point Likert scales. “Don’t know” and blank responses were coded as missing. Six adapted HBM-items were reverse scored prior to a calculation of HBM. Any construct with a Cronbach's alpha result < 0.7 was reported in the individual scale item. Previous studies have used a similar approach (Stephenson *et al.,* 2011; Edelson *et al,* 2009).

Paired t-tests (pre/post adapted HBM attitude, pre/revisited adapted HBM attitude and post/revisited adapted HBM attitude scores) were computed for each participant. A significant difference was noted before and after the intervention if $p < 0.05$.

4.6 Measurement of intermediate intervention

Using hearing protection such as earplugs and earmuffs can be used as an option to control noise when it cannot be lowered by any other means (Prince *et al.,* 2004; Rabinowitz, 2001). The effectiveness of hearing protection depends on how regularly they are used by employees (Paolucci, 2007). The intermediate assessment of the noise awareness training intervention measured the use of hearing protection in the 3 participating venues before and after the intervention.

4.6.1 Increase in hearing protection use

In the demographics section of each noise awareness questionnaire there was a question related to hearing protection use. Based on the questions used by Edelson *et al.,* (2009) the first questionnaire completed by training participants enquired:

"How often do you currently wear hearing protection in your workplace?"

The second questionnaire, completed immediately after attending the training asked

"How often do you plan to wear hearing protection in your workplace in the future?"

The third questionnaire, completed 6-8 weeks following attendance at the training again enquired

"How often do you currently wear hearing protection in your workplace?"

Five possible responses were

- Never
- Less than 10% of my work shift
- Between 10-50% of my work shift
- Between 51-90% of my work shift
- More than 90% of my work shift

In addition, the adapted HBM questionnaire asked employees 2 questions related to their behavioural intentions regarding hearing protection. This adapted HBM construct was measured using the 5-point Likert scale. A paired sample T-test was conducted to identify whether there was a significant difference in participants intentions following the noise awareness training intervention.

4.6.2 Change in safety culture

There is an increasing recognition that safety solutions based solely on engineering control measures and compliance with legislation will fail if attitudes to safety are poor (Williamson *et al.,* 1997). The Health and Safety Authority (HSA) "Noise of Music" guidance indicated that raising noise awareness may require a considerable shift in "both personal attitudes and the collective culture" (HSA, 2009). No previous research in Ireland has attempted to measure the attitudes and culture of the employees in the nightclub industry.

The use of hearing protection is influenced by safety climate (Zohar, 2006; Arezes, 2005). Putting in place noise controls is difficult if there is a safety culture that is reluctant to adopt the changes or is fatalistic in its beliefs (Institution of Occupational Safety and Health, 2004).

All 3 venues who participated in the intervention study also completed a 26-item questionnaire related to safety culture (please refer to Appendix 14 for a list of the questions used to assess the safety culture of venues, organised under the construct headings to which they apply). In the safety culture questionnaire completed by the noise awareness training participants, the construct items were randomised and not laid out under headings.

4.6.2.1 Safety culture questionnaire

The safety culture questionnaire, constructed from 6 factors had a 5-point Likert scale for all items (rated from strongly agree to strongly disagree) after each statement.

The 6 safety culture factors were:

1. Personal motivation.
2. Positive safety practice.
3. Risk justification.
4. Fatalism.
5. Optimism.
6. Safety climate.

This questionnaire was completed by the intervention participants to give an indication of the prevailing safety culture in the venue by questioning the prevailing attitudes and perceptions of the employees. Eight weeks after the training session was delivered, the questionnaire was re-administered to the training and control groups at both workplaces.

The safety culture scales used in this research were adapted from scales developed used by Stephenson *et al*, (2011); Edelson *et al.*, (2009); Trabeau *et al.*, (2008); Williamson, (1997). All data was entered into SPSS, negative items were reverse scored and each safety culture factor was tallied using the "Transform" function in SPSS. Then an overall safety culture was generated for each participant immediately post training and 8 weeks later.

4.6.2.2. Analysis

A reliability analysis was performed on all 26-items related to the safety culture using Cronbach's alpha test. ANOVA analysis was applied to see whether there was a significant difference between the 3 venues that may affect the training effectiveness.

The control groups' demographics were compared with the training intervention group. A repeated measures ANOVA was also used to assess whether the safety culture perceptions were altered by the training session. The overall scale and 6 sub-set scales were examined.

4.7 Chapter summary

Many of the studies conducted on noise exposure in nightclubs have focused on the effect that noise levels have on temporary threshold shifts in hearing. Previous studies have not examined interventions to reduce the noise exposure the employees' experience. The overall goal of the noise risk communication aspect of this study was to develop a noise awareness training programme and to conduct a pilot study to assess the effectiveness of such a training programme.

Manager interviews and employee questionnaires were used to quantitatively measure knowledge of the Noise Regulations, 2007 requirements and to explore stakeholders' attitudes. Five focus groups were used to collect qualitative data on participants' opinions and behaviours: the findings were used to develop a pilot study of noise awareness training content for the industry.

Previously occupational safety interventions have been criticised for not seeking sufficient evidence of the effectiveness of interventions (Goldenhar and Schulte, 1994;

Shannon, Robson and Guastello, 1999). In this thesis a quasi experimental non-randomised design was used where venues were assigned into an intervention group (training delivered) or a control group (no training delivered). Methods used to measure the immediate and intermediate intervention outcomes were also presented in this chapter.

Chapter 7 of this thesis will present the noise risk communication data and observations from interviews, questionnaires, focus groups and results from the training intervention designed to raise awareness of effects of noise on health and to promote the wearing of hearing protection.

Chapter 5

RESULTS

Noise Risk Assessment

5.0 Introduction

The data and observations for the 3 strands of noise risk analysis, as applied to twenty nightclub and discobar premises, will be presented in the next 3 chapters. This current chapter will present the noise risk assessment results. Sections 5.1 to section 5.3 are presented under the subheadings; hazard identification, hazard characterisation and risk characterisation.

In total, 126 nightclubs in Leinster were invited to become involved in this research. Discobar managers were also invited to be involved if they were listed as members on the INIA website. Although 26 managers initially agreed to be involved in the research 6 withdrew from the study. In total, 13 nightclubs and 7 discobar venues participated in the research. The response rate for venue participation was 16%. Reasons for declining participation included: lack of time and fear of the implications of not being compliant with regulations. All participating venues were assigned letters or numbers *e.g.* Nightclub A or Discobar 1 (hereinafter Club A or DB 1).

The analysis of the noise risk assessment results split the venues *i.e.* nightclubs and discobars, into two distinct categories since nightclubs were significantly louder than discobars.

5.1 Risk assessment – Hazard identification

Ten venues were visited in Dublin city and 10 venues in Leinster towns located in counties: Carlow, Kildare, Kilkenny, Meath and Westmeath. The venues were either attached to a hotel (45%), above or below a bar (20%) or standalone venues (35%).

5.1.1 Venue manager interviews

The following data/observations are based on initial visits to the twenty venues. Club B, Club C and Club J were the only venues not members of the Irish Nightclub Industry Association (INIA). Club I had 2 designated dance-floors while the rest all had 1 designated dance-floor.

5.1.1.1 Operating hours of participating venues

Table 5.1 shows the nights for which nightclubs and discobars were open and their opening hours. Unless otherwise indicated, the opening hours of nightclubs were 23:30-03:00 and the opening hours of the discobar venues were 12:00-03:00. The table shows the number of hours the discobar operated as an amplified music venue (comparable to a nightclub), highlighted in **bold**. Unless otherwise specified the discobar amplified music began at 22:00 and ran until 03:00.

The mean number of hours for which a nightclub was open per week was 13.0h (Standard Deviation (SD) 4.7h, range 5.5h – 24h). Discobars had a higher mean (M = 94.5h, SD 6.4h) than nightclubs but when the operating hours comparable to a nightclub were identified i.e. amplified music playing from 22:00 to closing time, the discobars mean operating hours per week was 18.8h (SD 9.3h, range 9h – 35h). An independent T-test indicted that there was no significant difference between the operating hours of a discobar and a nightclub venue (t (20) = -1.544, p = 0.163, two-tailed). While the Dublin based venues had longer operating hours (M= 16.7h, SD= 5.85h) than the Leinster town venues (M= 13.4h, SD=7.94h), an independent T-test indicated that there was no significant difference between the operating hours (t (20) = 1.034, p = 0.315).

Table 5.1: Location and operating hours of the thirteen participating nightclub venues

	Location	Venue Type	Opening nights	Number of nights open	Hours open per week	Patron capacity	No. of employees	Music genre
Club A	Town	Above a bar	Thurs^ - Sun x	4	11.5	500 - 1000	40	Pop/R&B
Club B	City Centre	Nightclub venue	Thurs y – Mon x	5	19	500 - 1000	24	Dance/Rave
Club C	Town	Attached to hotel	Fri – Sun x	3	9.5	500 - 1000	13	Pop/R&B
Club D	Town	Above a bar	Thurs –Sat	3	10.5	500 - 1000	28	All
Club E	City Centre	Attached to hotel	Thurs – Sat y	3	12	1000 +	15	Pop/R&B
Club F	Town	Attached to hotel	Thurs – Sun+	4	12.75	1000 +	60	Pop/R&B
Club G	City Centre	Attached to hotel	Wed – Sat y	4	16.5	500 - 1000	14	Pop/R&B
Club H	Town	Above a bar	Sat^ – Sun x	2	5.5	1000 +	22	Pop/R&B
Club I	Town	Attached to hotel	Wed^ – Sun x	5	14	500 - 1000	31	All
Club J	Town	Above a bar	Mon, Wed &Sat	3	10.5	500 - 1000	16	Pop/R&B
Club K	Town	Attached to hotel	Thurs – Sun	4	13	500 - 1000	22	Pop/R&B
Club L	City Centre	Nightclub venue	Mon- Sat y	6	24	500 - 1000	25	Pop/R&B
Club M	City Centre	Above a bar	Fri - Sun	3	10.5	500 - 1000	13	Pop/R&B

^ **Opening hours 23:30 – 02:30 except on Sunday**

x **Opening hours Sunday 23:30 – 02:00**

y **Opening hours 23:00 – 03:00 except on Sunday.**

\+ **Opening hours Thursday – Sunday were 23:00 – 02:15.**

Table 5.1 (Continued): Location and operating hours of the seven participating discobar venues

	Location	Type of venue	Opening nights Late nights	Number of nights open	Opening/Late hours open per week	Patron capacity	No. of employees	Music genre
DB 1	City Centre	Attached to hotel	Mon – Sun **Fri -Sat[z]**	7 **2**	86 **9**	200- 500	6	Dance/Rave
DB 2	City Centre	Attached to hotel	Mon – Sun **Mon - Sat[z]**	7 **6**	100 **27**	500 -1000	25	Dance/Rave
DB 3	City Centre	Attached to hotel	Mon – Sun **Thurs - Sat**	7 **3**	93 **15**	200- 500	Unknown	Pop/R&B
DB 4	Town	Attached to hotel	Mon - Sun **Thurs – Sat[y]**	7 **3**	92 **12**	200 -500	20	Pop/R&B
DB 5	City Centre	Standalone bar venue	Mon – Sun **Wed - Sat**	7 **4**	96 **20**	+1000	65	Pop/R&B
DB 6	City Centre	Standalone bar venue	Mon – Sun **Thurs - Sat[z]**	7 **3**	89.5 **13.5**	200- 500	30	Pop/R&B
DB 7	Town	Standalone bar venue	Mon – Sun **Mon - Sun**	7 **7**	105 **35**	200- 500	Unknown	Pop/R&B

Note: Bold highlighting in opening nights/late nights column signifies equivalent comparable operating hours to nightclub venues

[x] **Equivalent nightclub opening hours 22:00 – 02:00** [y] **Equivalent nightclub opening hours 22:00 – 02:30**

[z] **Equivalent nightclub opening hours 22:00 – 03:00**

Due to the provisions of the Intoxicating Liquor Act, 2008, no amplified music entertainment is permitted to be played during the 30 minute drink up time from 02:30-03:00 (Irish Government, 2008). Therefore, the number of hours a venue employee is exposed to amplified music was slightly less than the number of hours shown in Table 5.1 on pages 110 and 111. The majority of venues had a patron capacity between 500-1000 (55%).

5.1.1.2 Venue design

The design features were recorded for 90% of the venues (18/20). As expected all venue designs differed from each other. A Mann-Whitney U Test independent T-test was conducted between nightclubs and discobars for each of the observed design features. In the following cases p was greater than 0.05:

- The venues were usually on 1 (40%) or 2 floor levels (45%), Club A, Club D and Club M were spread out over 3 floor levels.
- All nightclub venues had at least 2 bars. The maximum number of bars in a venue was 4. Nightclub dance-floors (M =5.0m, SD =2.1) were almost 1m further from the nearest bar than discobars (M = 4.1m, SD = 6.5).
- Dance-floors in nightclubs represented a greater percentage of the total area of the venue (M = 14.4%, SD = 3.73) than discobar venues (M = 11.5%, SD = 3.82).
- The total mean area of the nightclubs (M = 422.0m, SD = 117.2) was larger than the total mean area of the discobars (M = 344.8m, SD = 189.8).
- Both types of venues had a similar mean number of speakers in the venue, nightclubs had M = 15.92 speakers (SD = 6.7) and discobars had M = 15.4 speakers (SD = 7.3).

The Mann-Whitney U Test showed that the mean age of sound systems in discobars (M = 8.8years, SD = 3.83) was significantly greater than the mean age of sound systems in nightclubs by more than three years (M = 5.2 years, SD = 3.13, $p < 0.05$).

5.1.1.3 Control of the music in the venues

The control of the music level in nightclubs and discobars rested with the Disc Jockeys (hereinafter DJ) in 88.8% of cases. The exceptions were Club B, where sound engineers had control over the music level, and DB 1, where the bartenders controlled the music level. While nightclub management did not have direct control, they carried out listening checks and instructed the DJ to adjust the volume up or down depending on their assessment of the atmosphere in the nightclub.

5.1.1.4 Number of staff employed in the venues

Due to the schedules of venue managers, only 18 were interviewed during the initial visits (response rate = 80%). There was a total of 469 staff employed across the 18 venues. The majority of nightclub employees were part-time (72%) while 43% of employees in discobars were part-time. The median hours worked by full-time nightclub and discobar employees were 39h and 40h respectively. Both part-time nightclub and discobar employees worked a median 18h**.** The full-time employees had a working range of 18-45h. The part-time venue employees had a working range of 9-24h.

5.1.1.5 Rotation of staff in each venue

Staff rotation between different locations in the venues was not common practice. Managers explained that their most experienced bartenders worked in the bar closest to the dance-floor because it was the busiest. Generally if a bartender commenced work in the bar closest to the dance-floor they continued to work in that bar for the duration of their work-shift. DB 5 was the only venue to rotate the bartenders between bars on different nights, for example if employee 1 worked in the bar area closet to the dance-floor on a Friday night then he/she was assigned to work in a bar area located 9.6m from the dance-floor on the Saturday night. In Club F and Club I, cloakroom employees were rotated from the cloakroom area to glass collecting duties half way through their work-shifts (for approximately 2 hours).

5.1.2 Employee noise questionnaire results

In the 20 venues visited, there were approximately 500 employees in total. The questionnaires were completed by eighty employees who were present during the initial visits to the venues: this led to a response rate of 16%.

5.1.2.1 Demographic data for participating employees

The majority of questionnaires were completed by bartenders (84%) although all varieties of employees were covered, namely supervisors 6%, glass collectors 6%, security personnel 1%, cloakroom staff 1% and DJs 1%. There were 5% of employees who did not respond to the query related to their age. The majority of employees were aged between 20-25 years old (51%). Only 9% were younger than 20 years old while 35% were 26 years old or older.

There was a significant difference between the mean age of the employees in nightclubs (M= 24.3 years, SD= 5.5) and those in discobars (M=28.0 years, SD= 6.37; t (76) = -2.58, *p*= 0.012, two-tailed). A significant difference was also found between the number of years spent working in nightclubs (M = 4.9 years, SD= 4.69) and discobars (M= 8.4 years, SD= 7.28) (t (80) = -2.2, *p* = 0.035, two-tailed) as analysed by an independent T-test.

5.1.2.2 Tasks carried out by bartenders

The tasks carried out by venue employees, along with the average number of hours spent at these tasks, were documented using the employee noise questionnaire. Bartenders carried out a variety of tasks other than serving customers behind the bar. On average, stocktaking was carried out by bartenders for less than an hour a night and cleaning out of hours lasted for an hour. More than two thirds of the nightclub bartenders had worked in another bar prior to their work-shift in the nightclub, for an average of 2.7h. Glass bottle disposal was carried out by 16% of bartenders.

5.1.2.3 Tasks carried out by other venue employees

An independent T-test showed that the duration of tasks carried out by other venue employees in nightclubs and discobars was not significantly different ($p < 0.05$). Data was gathered using the employee noise questionnaire. Employees ticked the tasks they carried out during their work-shift and noted the time they spent at the tasks. The average time taken at tasks was then calculated for each category of employee. As illustrated in Figure 5.1, glass collectors carried out a variety of tasks during their work-shift ranging from stock-taking and cleaning out of hours to working behind bars, disposing of glass bottles and working in ticket/cloakroom areas. Security personnel were located between dance-floor and the cloakrooms or outdoor areas.

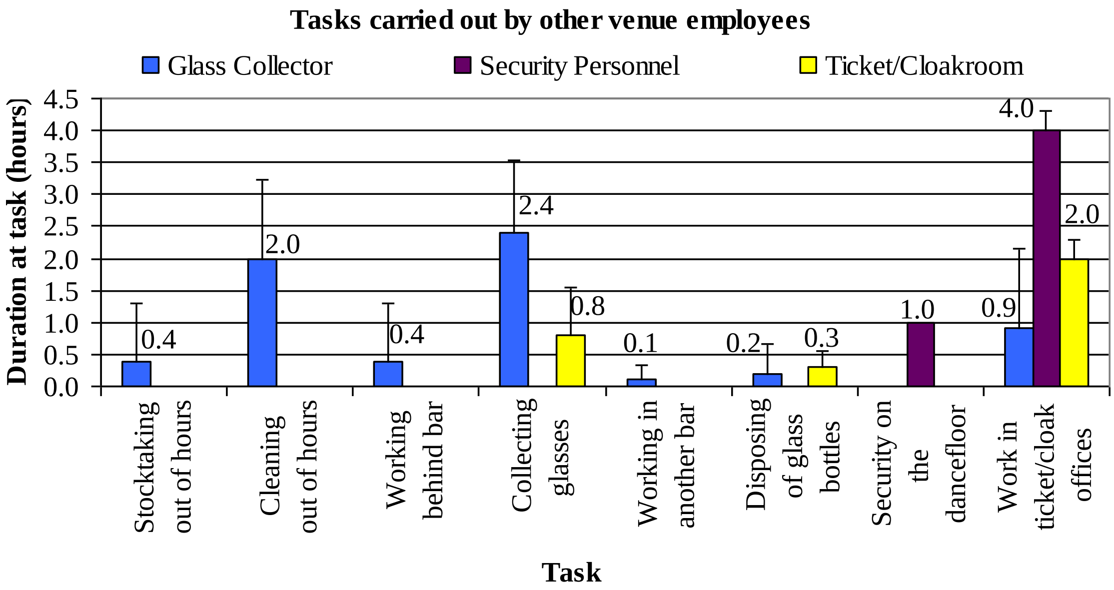


Figure 5.1: Tasks carried out by other venue employees and duration of task, including standard deviation error bars.

5.1.2.4 Employee work breaks

Discobar employees had a mean duration of work breaks of 33.9 minutes, while nightclub employees took a mean 16.6 minutes. The nightclub employees most commonly took their work breaks in a canteen area (36%) while the discobar employees took their work breaks outside in a smoking area attached to the discobar venue (36%). Employees in 6 nightclubs did not take work breaks during their shift.

5.1.2.5 Additional personal noise exposure excluding venue

Personal stereos/MP3/IPods were owned by 75% (57/76) of the venue employees and were used for a mean 5.34h (SD= 7.13, range 0-45h) per week. A chi-squared test for independence indicated a significant association between age (categorised) and the use of an MP3 player, χ^2 (1, n= 76) = 0.0383, p = 0.011, Cramer's V = 0.383). Using Cohen's (1988) criteria, a Cramer's V value greater than 0.3 is a medium effect. The mean age of an employee owning a personal stereo was 24 years compared to the mean age 29.7 years of an employee who did not own a personal stereo. Note: A limitation with the computed chi-square analysis was that 3 cells (37.5%) had an expected count less than 5. Normally for the chi-square analysis the expected cell-count should be at least 5 for 80% of cells (Pallant, 2010).

5.2 Risk assessment – Hazard characterisation

To carry out a comprehensive noise hazard characterisation in Leinster venues, a total of 378.5 hours of noise monitoring took place. The majority of data was collected using dosimeters in 13 nightclubs and 7 discobar venues. This surveillance lasted for a total of 177 hours in nightclubs and 127 hours in discobars. Results were analysed using the Bruel and Kjær Protector software which produced a time history report of the dosimeter data. Bartenders who wore the dosimeters were observed during their work-shifts and design features of the venues were documented on the evening prior to the venue opening to the public. This data was used to gain an understanding of the bartenders general work activities and to calculate the $L_{EX,\ 8h}$ and $\bar{L}_{EX,\ 8h}$. A mobile sound level meter (SLM) was used to measure the L_{Aeq} and L_{Cpeak} levels to which other venue employees were exposed to calculate their $L_{EX,\ 8h}$ and $\bar{L}_{EX,\ 8h}$.

A fixed position SLM was placed in the bar area closest to the dance-floor area of each venue to measure the typical noise levels over time in the venue and the dominant frequencies emanating from the music played in the venue. Unannounced visits were conducted in 10 venues in Dublin to gather data on the possible effect that announced visits might have had on the noise levels observed.

5.2.1 Bartender dosimeter results

The noise exposure of 100 bartenders was collected using dosimeters. On 5 occasions a dosimeter had a fault at the end of the night: this may have been due to the battery failing or the microphone jack becoming disconnected from the body of the dosimeter. The mean sample duration was 188 minutes in each venue (SD 62, range 83 – 390 minutes). Discobars (Mean = 222.1, SD 58.3) had a significantly longer sample duration time than nightclubs (Mean = 170.5, SD 58; $p < 0.01$). This was not unexpected as an independent T-test showed bartenders in discobar venues had a significantly longer work-shift (M=8.7h, SD=1.2h) than bartenders in nightclub venues (M=4.3h, SD=0.8h; $t(93) = -20.9$, $p < 0.01$).

5.2.1.1 Bartender L_{Aeq} inter-personal variability due to glass disposal

The inter-personal variability of dosimeter 1 and dosimeter 2 in each venue was explored using paired samples T-tests. There was no significant difference between the L_{Aeq} for tasks carried out by dosimeter 1 and dosimeter 2 ($p > 0.05$) in all cases.

Five bartenders were observed carrying out glass disposal during their work-shift while wearing the dosimeters. For example in Club F while the L_{Aeq} was measured as 98.4 dBA for bartender 2 during the stocking of the bar, the L_{Aeq} was lower for bartender 1 at 88.0 dBA. The reason for this difference was that bartender 2 went to dispose of glass bottles. A similar difference was observed in Club J when the bartender wearing dosimeter 1 used part of his time to dispose of glass bottles and had a higher L_{Aeq} for this section of the monitoring than a co-worker who was stocking the bar. Both of these examples clearly show that the noise level when disposing of glass bottles can be high, however no noise measurements were taken specifically to explore the importance of glass disposal for bartenders L_{Aeq} during tasks.

5.2.1.2 Bartender L_{Aeq} inter-personal variability due to bar shape

During the visits to the venues, the designs of the bars were documented along with the location of bartenders wearing dosimeter 1 and dosimeter 2. The mean difference between bartenders L_{Aeq} while working in a linear bar during venue operation was 1.6 dBA louder (M= 95.0 dBA, SD 4.4) compared to curved bars (M= 93.4 dBA, SD 6.5). As there was no significant difference between the two bars, it was decided that it was not feasible to examine bar shape in greater detail ($p > 0.05$).

5.2.1.3 Differences between venues in task L_{Aeq} levels

Dosimeter measurements were used to establish the L_{Aeq} of 3 tasks carried out by bartenders in nightclubs and discobars. As illustrated in Figure 5.2, a 0.1 dBA difference existed between the mean L_{Aeq} levels measured during DJ sound checks in the discobar and nightclub venues. An independent samples T-test was conducted to compare the task L_{Aeq} in discobars and nightclubs. There was only a significant difference between nightclubs and discobars L_{Aeq} when the DJ played music for patrons *i.e.* excluding sound check. For discobars the mean was 92.1 dBA (SD 5.9) and nightclubs (M= 95.6, SD 4.5; t (94) = 3.23, $p < 0.01$). The statistical magnitude of the differences in the means was small (eta squared = 0.10).

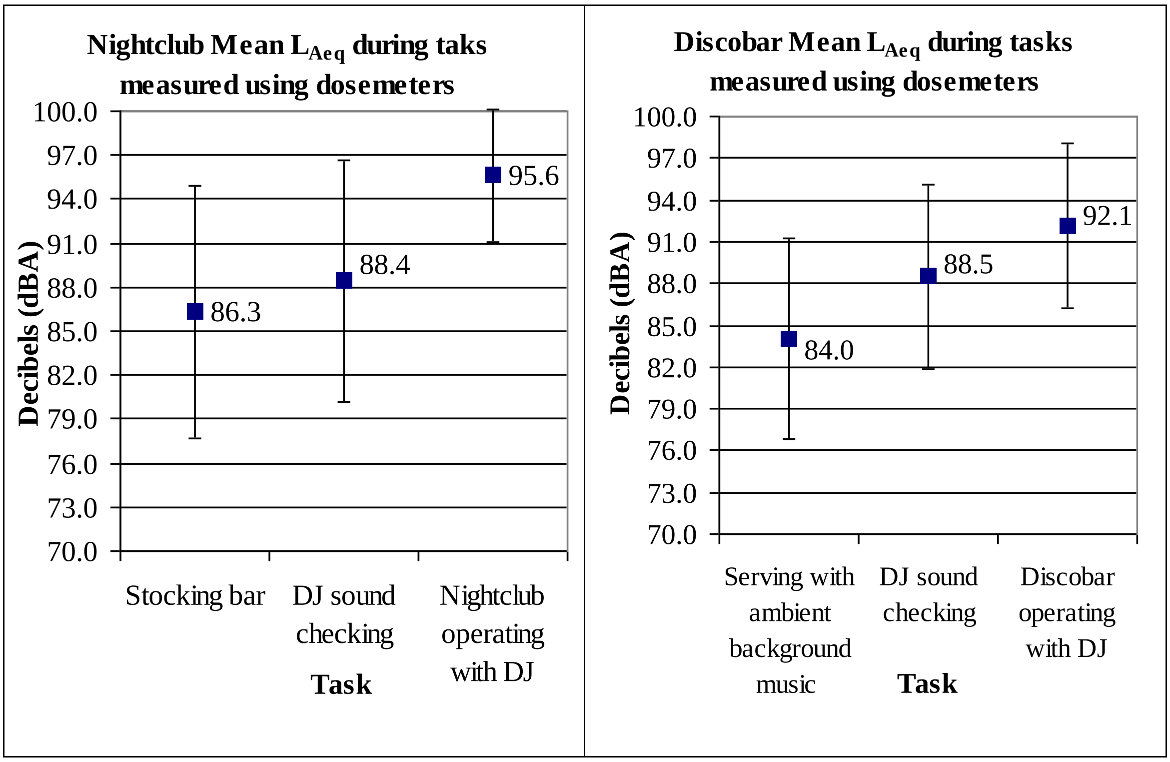


Figure 5.2: Mean L_{Aeq} measured in discobars and nightclubs during 3 tasks carried out by bartenders

5.2.1.4 L_{Cpeak} measurements for bartenders

Figure 5.3 and Figure 5.4 compare the peak C-weighted levels (L_{Cpeak}) experienced by nightclub and discobar bartenders in the bar area closest to the dance-floor. There were 24 bartenders out of 95 valid measurements, 25.3%, that were exposed to L_{Cpeak} levels above 140 dBC. An independent T-test confirmed there was no significant difference between the mean L_{Cpeak} level for bartenders in nightclubs (135.0 dBC) and discobar venues (135.2 dBC; $p > 0.05$).

A chi-squared test indicated no significant association between venue type and compliance with the L_{Cpeak} lower/upper exposure action values and exposure limit value, $\chi^2(3, n= 95) = p > 0.05$, *phi* = 0.124. Note: A limitation with the computed chi-square analysis was that 2 cells (25%) had an expected count less than 5. Half of the bartenders (48/95) were below the L_{Cpeak} lower exposure action value (135 dBC).

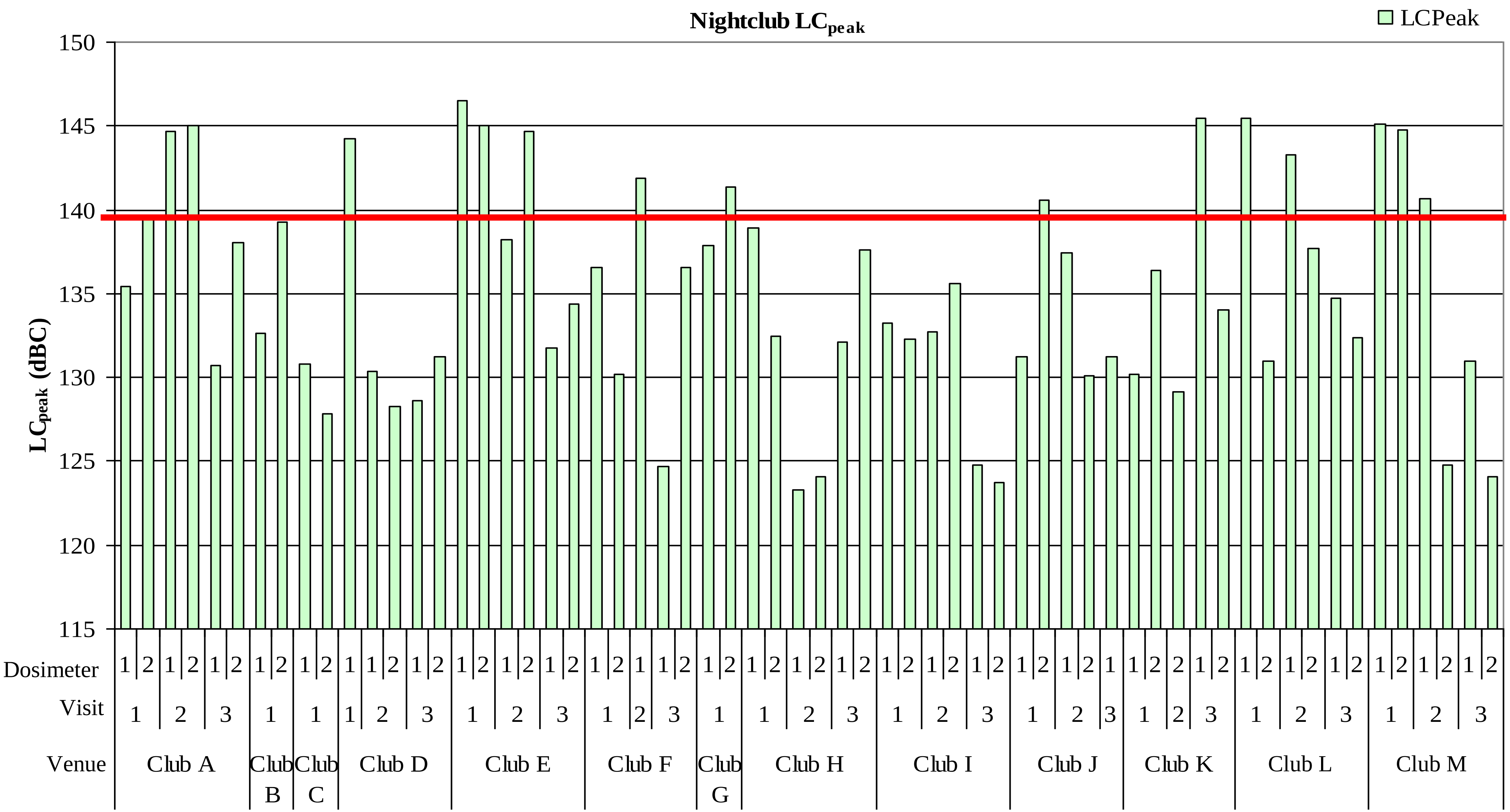


Figure 5.3: Summary of dosimeter 1 and dosimeter 2 L_{Cpeak}s for bartenders in nightclub venues, based on measurement day

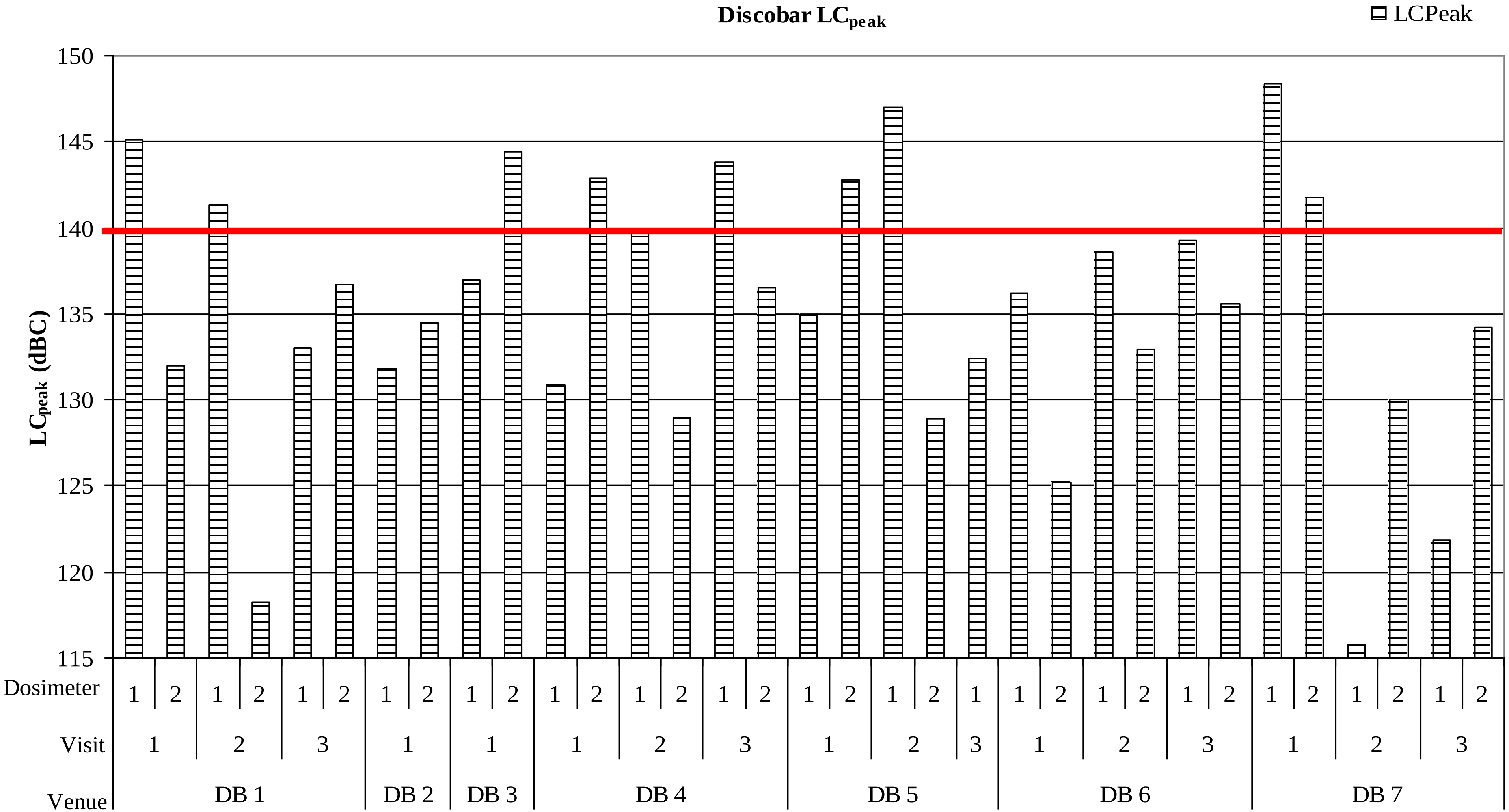


Figure 5.4: Summary of dosimeter 1 and dosimeter 2 L_{Cpeak}s for bartenders in discobar venues, based on measurement day

5.2.2 Mobile sound level meter (SLM)

Mobile SLM measurements were recorded for all groups of employees in the venues that were visited 3 times during this fieldwork (n = 15). In total 443 5-minute measurements were recorded for all other venue employees excluding glass collectors, giving the sample duration of 36.9h in total. Glass collectors were sampled for a shorter time due to their high mobility. In total 193 measurements of 20-seconds duration were recorded for each glass collector.

5.2.2.1 Relationship between noise level and time of measurement

Noise measurements were taken at positions corresponding to an employee's ears and at times when the employees would usually be present in the venue carrying out their various tasks. The measurements were conducted between 21:00 and 01:00. The relationship between the L_{Aeq} and time was investigated using Pearson correlation co-efficient, where n = 635. There was a positive medium effect correlation between employees L_{Aeq} and time (r = 0.41, $p < 0.05$), which meant that as time passed, the L_{Aeq} experienced by employees increased. L_{Cpeak} also rose over time, as shown with the Pearson medium effect correlation co-efficient (r = 0.38, $p < 0.05$).

5.2.2.2 Mean L_{Aeq} of other venue employees

A one-way, between groups, analysis of variance (hereinafter ANOVA) was conducted to explore the impact of job title of the other venue employees on the L_{Aeq} levels that they experienced. The other venue employees consisted of bartenders working in bars not located closest to the dance-other in the venue, glass collectors, security personnel and cloakroom/ticket desk attendants. There was a statistically significant difference the employees L_{Aeq} and job title at the $p < 0.05$ level: $F (6,628) = 30.1$.

Noise levels were measured in the venues only when employees were present. The mean L_{Aeq} they experienced rose when the music began in the venue, usually at 23:00 in nightclubs and 22:00 in discobar venues. Music playing inside the venue increased the mean L_{Aeq} that security personnel located outside the venue experienced by roughly 2 dBA (see Figure 5.5).

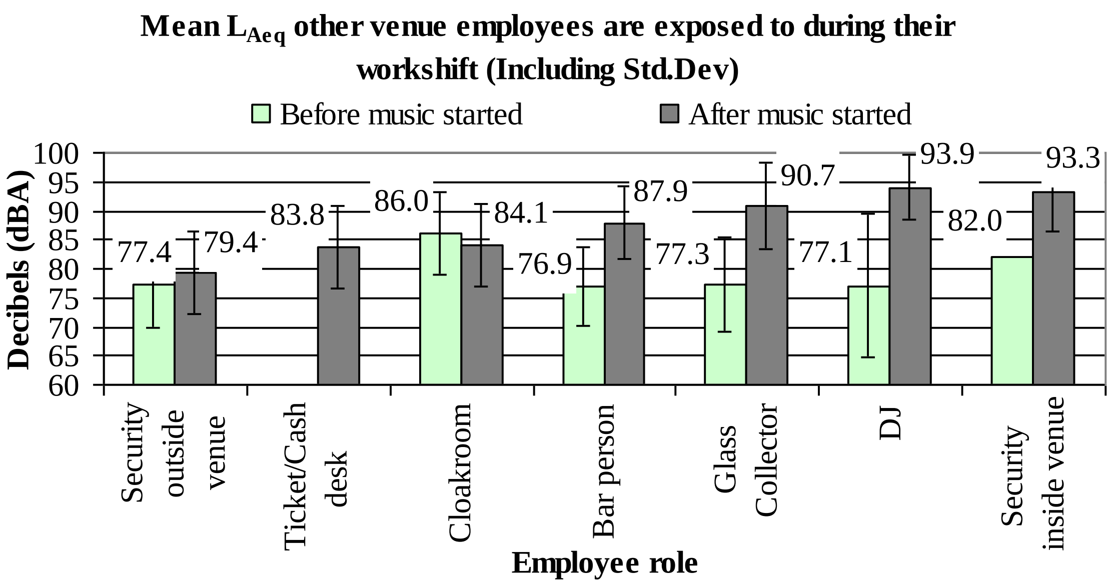


Figure 5.5: Mean L_{Aeq} other venue employees were exposed to before and during amplified music playing in the venue

5.2.2.3 L_{Cpeak} measurements for other venue employees

None of the other venue employees' L_{Cpeak} exceeded the lower exposure action value (135 dBC).

5.2.2.4 Difference between employee L_{Aeq} and L_{Cpeak} and venue type

All venue employees, excluding bartenders in the bar area closest to the dance-floor, were exposed to a higher mean L_{Aeq} in nightclubs than discobar venues, as summarised in Table 5.2. A split file (role) independent T-test was conducted between nightclub and discobar venues for two parameters: L_{Aeq} and L_{Cpeak}. There was a significant difference between the L_{Aeq} experienced by employees in nightclubs and discobars ($p < 0.05$). This may have been due to the lower music volume in discobars while the DJ played (see Figure 5.2). Security personnel inside discobars were generally located near the door of the discobar, the security personnel inside nightclubs were located closer to the dance-floor area.

There was no significant difference between bartenders or DJs in nightclub and discobar bar venues ($p > 0.05$). The DJs and bartenders (those not in the bar closest to the dance-floor) were in similar locations in discobars and nightclubs *i.e.* the DJs in both types of venues were always located on the edge of the dance-floor. All mean nightclub and discobar venue L_{Cpeak} levels were significantly different for other venue employees ($p < 0.05$).

None of the discobars had a cloakroom or ticket/cash desk: hence it was not possible to explore whether there was a significant difference between these roles in nightclubs and discobars.

ANOVA was conducted to explore the impact of venue type and the location of a venue on specific L_{Aeq} levels measured for each type of employee (using the mobile SLM). Venues were divided into nightclubs/discobars and by where they were located. Based on the 7 roles other venue employees had, the interaction effect between venue type and location was not statistically significant for any role ($p > 0.05$).

Table 5.2: The mean L_{Aeq} measured in 15 venues, visited three times during fieldwork

	N	Nightclub Mean (SD)	N	Discobar Mean (SD)	*p* value
Other bartenders:	**153**				
Mean L_{Aeq}	71	88.4 dBA (7.9)	82	86.5 dBA (5.7)	0.099
Mean L_{Cpeak}	71	115.7 dBC (6.8)	82	110.7 dBC (5.0)	< 0.01
Glass collector:	**193**				
Mean L_{Aeq}	112	92.9 dBA (5.8)	81	86.7 dBA (8.9)	< 0.01
Mean L_{Cpeak}	112	118.1 dBC (7.0)	81	109.8 dBC (8.8)	< 0.01
Security inside:	**61**				
Mean L_{Aeq}	50	95.5 dBA (6.4)	11	82.3 dBA (5.5)	< 0.01
Mean L_{Cpeak}	50	121.1 dBC (4.5)	11	107.7 dBC (4.5)	< 0.01
Security outside:	**44**				
Mean L_{Aeq}	25	81.3 dBA (7.7)	19	76.4 dBA (5.0)	0.021
Mean L_{Cpeak}	25	111.0 dBC (8.0)	19	106.4 dBC (4.2)	0.018
DJ:	**102**				
Mean L_{Aeq}	68	93.7 dBA (7.6)	34	91.4 dBA (6.3)	0.128
Mean L_{Cpeak}	68	121.2 dBC (8.2)	34	116.9 dBC (4.6)	< 0.01
Cloakroom:	**55**				
Mean L_{Aeq}	55	84.2 dBA (7.0)	0		N/A
Mean L_{Cpeak}	55	113.5 dBC (7.1)	0		N/A
Tickets/cash desk:	**27**				
Mean L_{Aeq}	27	83.8 dBA (7.2)	0		N/A
Mean L_{Cpeak}	27	113.5 dBC (7.0)	0		N/A

5.2.3 Fixed SLM in bar area

The L_{Aeq}s were measured at 23:30, 00:15 and 01:00 each night in 15 venues over 3 measurements nights. In the 5 venues measured for only 1 night, the $L_{A,eq}$s were measured at the same 3 time intervals. This resulted in a fixed SLM L_{Aeq} sample of data of 150 measurements, totalling 21.5 hours of octave band measurements. In the 20 venues the SLM L_{Aeq} ranged from 69.2-101.9 dBA. Figure 5.6 shows the mean noise levels recorded in the nightclub venues over time, based on 95 measurements and in discobars based on 49 measurements.

During the operation of the nightclubs, the L_{Aeq} was observed to rise with time. The standard deviation in L_{Aeq} between nightclubs at 23:30 (6.0 dBA) was greater than at any other time of the night. As time passed, the standard deviation decreased: At 00:15, it was 4.3 dBA and at 01:00, it was 4.0 dBA. In discobars, the L_{Aeq} was not observed to rise as much over time as the nightclub venues. At 23:30 the mean L_{Aeq} in discobars (87 dBA) was, on average, 3 decibels lower than in nightclubs (90 dBA). In discobars, at 00:15, the standard deviation decreased (6.0 dBA) but rose again at 01:00 (7.0 dBA).

Although it would have been beneficial to continue measuring the noise level trend until it fell, this was not possible due to restricted access after 01:00 in the venues. The highest noise levels were expected between 00:30 to 01:00.

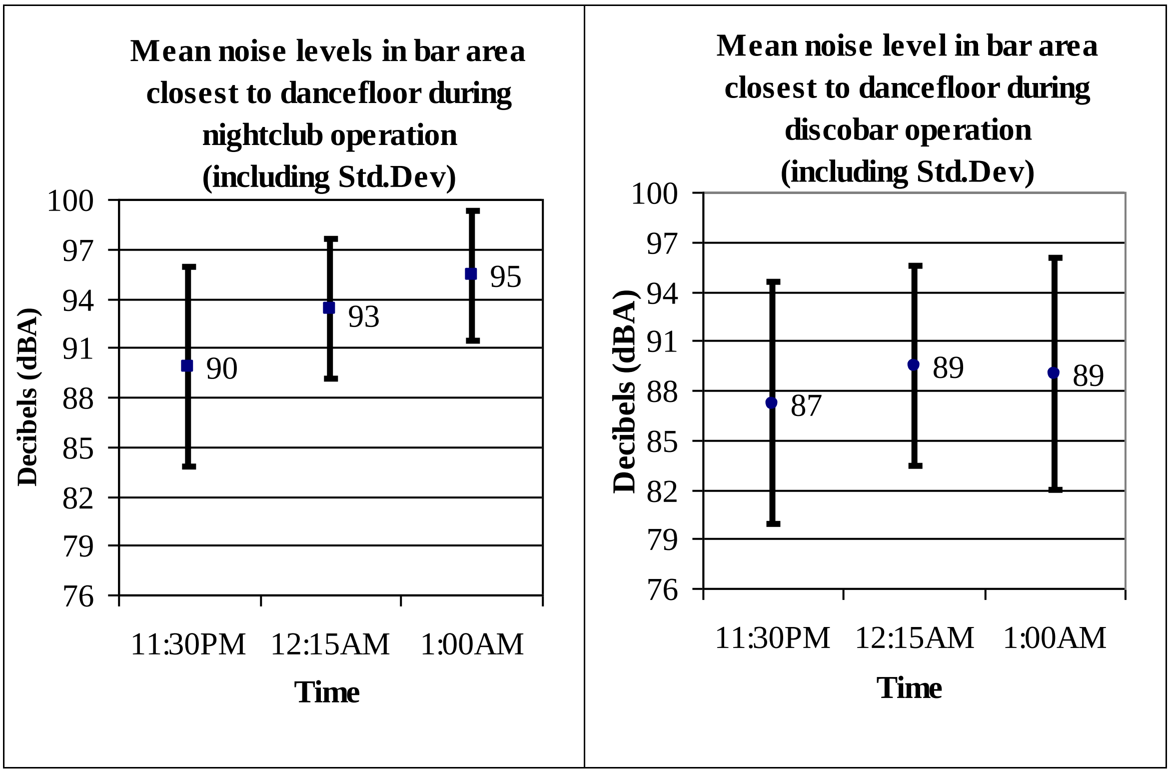


Figure 5.6: Mean L_{Aeq} noise levels, at three time intervals, measured by the fixed SLM in the bar areas closest to dance-floor in nightclubs and discobars.

The noise level rose from 23:30 to 01:00 by an average of 5 dBA (90 – 95 dBA) in nightclub venues and by 2 dBA in discobar venues. Similar findings have been reported in other studies and are referred to as the "cocktail effect" whereby the noise levels tend to rise over the course of the evening (Sadhra *et al*., 2002; Whitfield, 1998; Bickerdike and Gregory, 1980).

5.2.3.1 Analysis of fixed SLM data based on specific characteristics

Independent T-tests and ANOVA analysis were carried out on the 145 fixed area SLM measurements. Table 5.3 summarises the mean decibel measurements as a function of specific characteristics: category of venue, time of measurement, location of venue, type of venue, number of late nights venue was open, area of venue and distance of bar area from dance-floor in the venue. The *p* value for each characteristic was calculated, if $p < 0.05$ then a significant difference was noted.

Table 5.3: Mean fixed SLM L_{Aeq} in venues by selected characteristics

	Number of venues investigated	**Number of readings**	**Mean (SD) dBA**	**Range dBA**	***p* value**
Category of Venue					
Nightclub	13	96	92.8 (5.3)	73.3 – 101.9	< 0.01
Discobar	7	49	88.5 (6.8)	69.2 – 99.1	
Time					
11.30[a]	20	49	88.9 (6.6)	70.1 – 100.5	< 0.01[a]
00:15	20	48	92.0 (5.2)	76.5 – 101.9	
01:00	20	48	93.2 (5.9)	69.2 – 101.9	
Location					
Dublin	10	63	90.3 (5.2)	70.1 – 98.6	0.059
Leinster	10	82	92.2 (6.7)	69.2 – 101.9	
Type of venue					
Stand alone	6	42	91.6 (4.5)	81.8 – 99.1	0.025[b]
In a hotel[b]	9	58	89.9 (7.3)	69.2 – 100.3	
Above or below a bar	5	45	93.0 (5.5)	73.3 – 101.9	
Late nights open per week					
2	2	16	87.6 (8.0)	70.1 -100.1	0.061
3	7	51	91.3 (7.0)	69.2 – 101.9	
4	6	48	92.8 (3.9)	85.4 – 100.5	
5	5	30	91.2 (6.0)	76.5 – 99.1	
Area of venue					
<300 m^2[c]	4	28	88.3 (7.7)	69.2 – 100.5	0.045[c]
301 – 500 m^2	8	60	92.3 (5.3)	73.3 – 101.9	
>501 m^2	6	45	92.6 (5.0)	76.5 – 100.3	
Distance between bar and dance-floor					
< *5m*	12	91	91.3 (6.8)	69.2 – 101.9	0.891
>*5m*	8	54	91.5 (4.9)	73.3 – 100.1	
Total	**20**	**145**	**91.4 (6.2)**	**69.2 – 101.9**	

[a, b, c] denote which group of the variable was significantly different after post-hoc tests

An independent T-test confirmed that there was a significant difference in the mean L_{Aeq} levels measured in nightclubs and discobar venues ($p < 0.01$). The time of the L_{Aeq} measurements was also significantly different, as shown by ANOVA analysis ($p < 0.01$). Post-hoc comparisons using the Tukey test indicated that the mean L_{Aeq} for 23:30 was significantly different from the mean L_{Aeq} for 00:15 and 01:00 ($p < 0.05$). Venues that were attached to a hotel were significantly quieter (89.9 dBA) than venues that were either stand alone (91.6 dBA) or attached to a bar venue (93.0 dBA; $p < 0.05$). The smallest venues, defined as those with a total area of less than $300m^2$, were significantly quieter (88.3 dBA) than the larger venues $>300m^2$ (92.3 dBA and 92.6 dBA; $p < 0.05$). There was no significant difference between the venues located in Dublin city centre or in Leinster towns outside Dublin ($p > 0.05$).

5.2.3.2 Octave band frequency measurements for venues

Knowledge of the breakdown of the frequency bands was essential if suitable hearing protection was to be selected for the nightclub bartenders. The SLM placed in the bar area measured the 1/1 octave band frequencies. The octave band measurements were at 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. Figure 5.7 illustrates the mean octave band levels in nightclub and discobar venues.

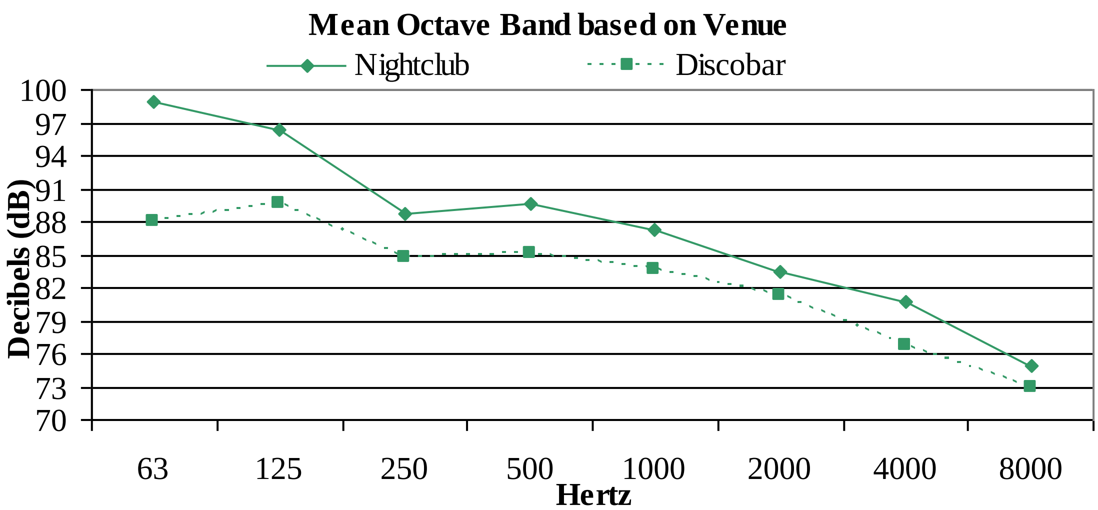


Figure 5.7: The eight mean octave bands in nightclubs and discobars

Independent T-tests confirmed that there was a significant difference between nightclubs and discobars in all octave band mean decibels readings apart from the octave band 8000 Hz ($p = 0.356$). As shown in Figure 5.7, nightclub venues had higher mean decibels levels in all octave bands; this may have been due to the significantly higher operating music levels in nightclubs (see Figure 5.2). The lower frequencies (63 and 125 Hz) were more prominent than the mid-to-high frequencies in both venue types.

ANOVA analysis verified that there was a significant difference between the mean decibels in all octave bands based on the type of music played ($p < 0.05$) apart from the octave band 2000 Hz ($p > 0.05$). An independent T-test confirmed that dance music (M= 87.9 dBA) was played at a significantly lower volume than pop music (M= 92.9 dBA) and a mixture of pop and dance music (M= 92.0 dBA; $p < 0.05$). The worst case octave band scenario from each venue was used to select suitable hearing protection for the bartenders (see Chapter 6 Results, Section 6.2).

5.2.4 Difference in mean L_{Aeq} in announced and unannounced visits to venues

In Dublin, 6 nightclubs and 4 discobars that were not previously involved in this research were visited unannounced and 2 dosimeters were used to measure the L_{Aeq} and L_{Cpeak} in the bar area closest to the dance-floor from 23:30 until 01:00. The mean parameters and standard deviations are summarised in Figure 5.8. A paired sample T-test was conducted separately in nightclubs and discobar venues to evaluate whether there was a significant difference between the L_{Aeq} and L_{Cpeak} measurement results in dosimeter 1 and dosimeter 2. No statistically significant difference in the L_{Aeq} and L_{Cpeak} measurements between either types of venue ($p > 0.05$) was found.

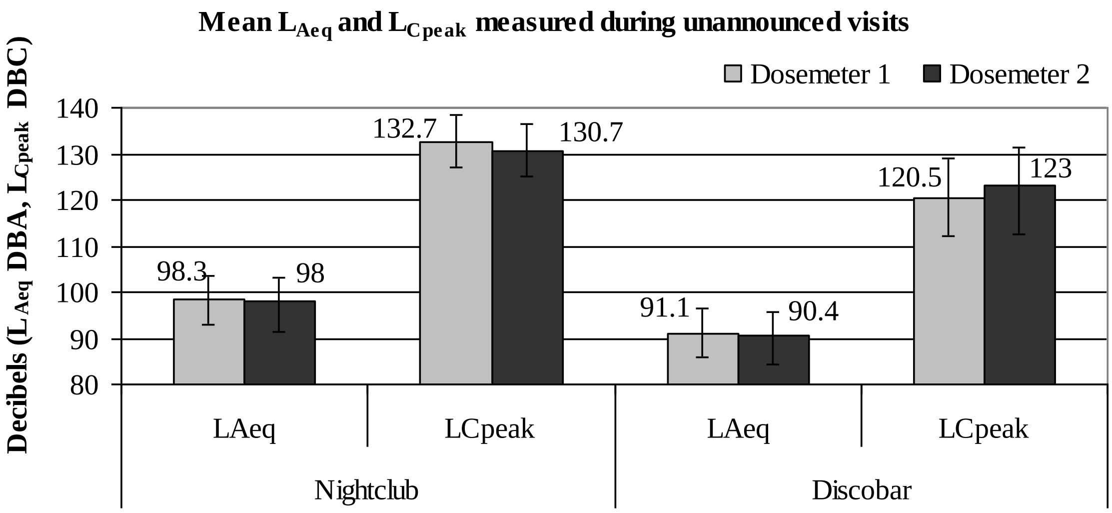


Figure 5.8: Graph of mean parameters measured using 2 dosimeters during unannounced visits in Dublin venues.

There was only 1 unannounced venue where the dosimeters had a difference in L_{Aeq} greater than 2.0 dBA between them. This difference may have occurred due to the dosimeters facing in different directions during the measurement period. A spilt file independent samples T-test was used to explore whether there was any difference between venue type and announced/unannounced visits. Figure 5.9 shows the mean L_{Aeq} recorded with the dosimeter in the venues. There was no significant difference found between the L_{Aeq} means of announced and unannounced visits ($p > 0.05$).

An independent T-test was conducted on Task 3 L_{Aeq} levels between venues in Dublin where the announced and unannounced visits took place. There was no significant difference between the L_{Aeq} task levels of nightclubs or discobars who knew monitoring was occurring and those who did not ($p = 0.167$, $p = 0.328$ respectively).

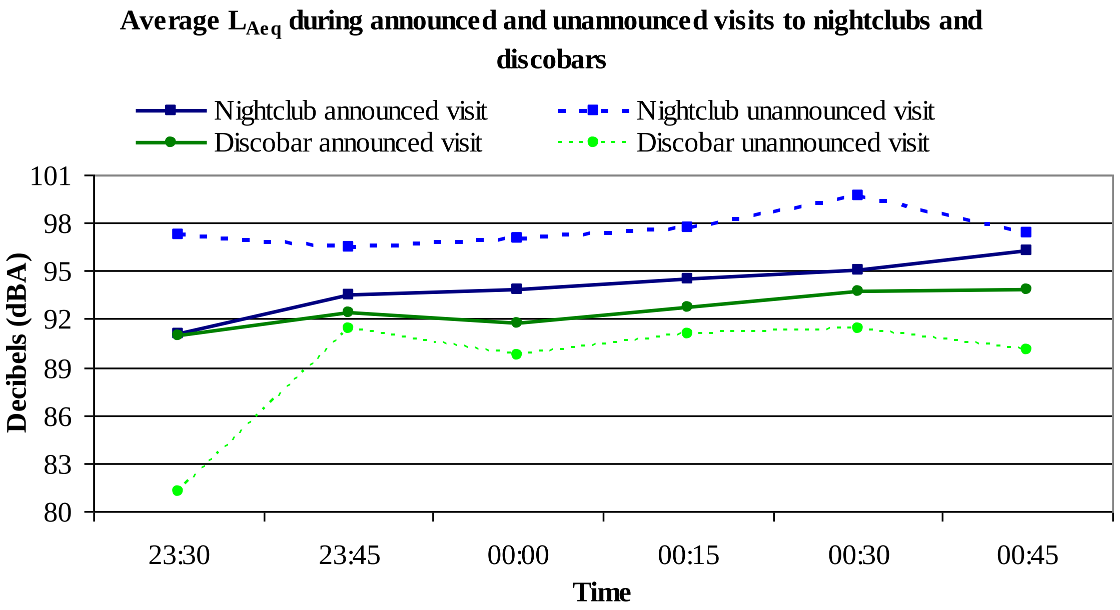


Figure 5.9: Mean noise levels for different types of venue over the duration of operation. (The data is taken from the summation of the continuous 5 minute L_{Aeq} samples from the dosimeter in the venues).

5.2.5 Estimation of bartenders $L_{EX,\ 8h}$

The worst-case scenario $L_{EX,8h}$ was calculated for each bartender working in the bar area closest to the dance-floor of the venue by inputting the L_{Aeq} noise level of tasks and the duration of time spent at that task into the ISO:1999 formulae.

5.2.5.1 Bartender inter-personal $L_{EX,\ 8h}$ variability

All venues had dosimeters placed on 2 bartenders in the same bar area. A paired sample T-test was conducted to evaluate whether there was a significant difference between dosimeter 1 task $L_{EX,\ 8h}$ and dosimeter 2 task $L_{EX,\ 8h.}$ There was no statistically significant difference in the task $L_{EX,\ 8h}$ between dosimeter 1 (M =92.1 dBA, SD = 3.3 dBA) and dosimeter 2 (M= 91.8, SD = 3.7 dBA), t (18) = 0.692, p = 0.50. This was also the case on measurement day 2 (dosimeter 1 M = 91.0 dBA, SD = 4.8dBA, dosimeter 2 M= 90.6 dBA SD= 5.1 dBA; t (12) = 0.302, p= 0.77) and measurement day 3 (dosimeter 1 M= 91.0 dBA, SD = 5.1 dBA, dosimeter 2 M= 89.9, SD = 6.9 dBA; t (12) = 1.526, p=0.15).

Glass disposal did have an impact on the overall $L_{EX,8h}$ between dosimeter 1 and dosimeter 2 in 3 of the venues: meaning the glass disposer had an $L_{EX,8h}$ more than 2.0 dBA higher than their colleagues (dosimeter 2).

Revisits and re-monitoring were conducted on 2 additional nights for 75% (15/20) of the venues. Dosimeters were once again placed on bartenders working in the same bar areas however, only 13% (2/15) of the $L_{EX, 8h}$ results were repeatable (within 1-2 dBA) over the 3 nights. This was not unexpected since different nights e.g. Friday/Saturday, were measured. When the same nights $L_{EX, 8h}$ in each venue was compared, *e.g.* initial visit measured on a Friday night and revisit was on a Friday night, 90% of nightclubs (9/10) and 60% of discobars (3/5) were repeatable within 1-2 dBA of each other.

5.2.5.2 Calculation of Task $L_{EX, 8h}$

The task $L_{EX, 8h}$ value was calculated from the L_{Aeq} values measured for each task carried out by the bartenders while wearing the dosimeters. Summarised data from the measurements are shown in Table 5.4-5.8, where the L_{Aeq} for the main tasks carried out by the 95 bartenders are grouped together by the size of the venue. Included in the table are: task based daily noise exposure ($L_{EX, 8h}$) and L_{Aeq} for each task carried out by either bartender wearing dosimeter 1 (D1) or dosimeter 2 (D2). Nightclub bartenders had mean $L_{EX, 8h}$ 92.3 dBA (SD=3.8 dBA, range =84.0-98.4 dBA) that was significantly higher than the mean $L_{EX, 8h}$ 89.1 dBA of discobar bartenders (SD 5.4 dBA, range = 71.4-98.4 dBA; $t (93) = 3.4$, $p < 0.01$).

The task $L_{EX, 8h}$ that exceeded the exposure limit value of 87 dBA are shaded black in the tables. The tables clearly indicate that the majority of bartenders working in the bar area closest to the dance-floor, 85% (81/95), exceeded the exposure limit value (87 dBA). Only 2 employees in discobars were found to be under the lower exposure action value (80 dBA). A Chi-squared test for independence indicated no significant association between venue and compliance with the lower/upper exposure action value or the exposure limit value, $\chi^2(3, n= 95) = p = 0.066$, *phi* = 0.275.

Grey shading was also added to the tables to highlight the tasks in each venue that required the bartenders to wear hearing protection when the noise level exceeded 85 dBA. The L_{Aeq} from each task was coded into 2 groups: Group 1, indicated where hearing protection must be worn, Group 2, where hearing protection was not required. Chi-squared analysis confirmed there was no significant difference between nightclub and discobar venues when their bartenders were required to wear hearing protection ($p > 0.05$). Once the bartender was exposed to amplified music they should have been wearing their hearing protection since the L_{Aeqs} exceeded 85 dBA in 84% (159/189) of task L_{Aeq} samples.

Table 5.4: Task L_{Aeq} and $L_{EX,8h}$ for the main tasks carried out by the bartenders in venues that were less than 300m² in area

		Club A		Club G		DB 1		DB 4	
		D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)
Day 1	**$L_{EX,8h}$**	**95.1**	**95.1**	**94.0**	**94.8**	**92.9**	**90.3**	**91.1**	**92.6**
	Task 1	-	-	-	-	70 for 4.5h	70 for 4.5h	63 for 2.5h	63 for 2.5h
	Task 2	-	-	88.6 for 2.5h	85.6 for 2.5h	89.9 for 2h	89.1 for 2h	79.6 for 2h	76.5 for 2h
	Task 3	86.7 for 0.5h	-	95.6 for 0.5h	98 for 0.5h	94.1 for 0.5h	90.5 for 0.5h	88.3 for 0.5h	87.7 for 0.5h
	Task 4	99.3 for 3h	99.4 for 3h	97.4 for 3h	98.3 for 3h	96.1 for 3h	93.3 for 3h	95.1 for 3h	96.7 for 3h
Day 2	**$L_{EX,8h}$**	**98.1**	**98.4**	**-**	**-**	**89.3**	**91.3**	**83.6**	**81.5**
	Task 1	-	-	-	-	70 for 4.5h	70 for 4.5h	63 for 2.5h	63 for 2.5h
	Task 2	103.2* for1h	96.4 for 1h	-	-	88.5 for 2h	89.6 for 2h	80 for 2h	79.2 for 2h
	Task 3	97.5 for 0.5h	97.7 for 0.5h	-	-	94.8 for 0.5h	95.2 for 0.5h	83.9 for 0.5h	83.1 for 0.5h
	Task 4	99.6 for 3h	102 for 3h	-	-	91 for 3h	93.9 for 3h	87 for 3h	84.5 for 3h
Day 3	**$L_{EX,8h}$**	**96.8**	**95.2**	**-**	**-**	**78.6**	**71.4**	**91.8**	**86.9**
	Task 1	-	-	-	-	70 for 4.5h	70 for 4.5h	63 for 2.5h	63 for 2.5h
	Task 2	100.6* for1h	82.8 for 1h	-	-	78 for 2h	70.3 for 2h	85.5 for 2h	84.6 for 2h
	Task 3	98.9 for 0.5h	82.2 for 0.5h	-	-	80.1 for 0.5h	69.6 for 0.5h	94.4 for 0.5h	88.2 for 0.5h
	Task 4	98.8 for 3h	99.4 for 3h	-	-	80.7 for 3h	71.2 for 3h	95.2 for 3h	90 for 3h

Key: Task 1: Before music begins in venue. **Task 2:** Stocktaking **Task3:** DJ sound check **Task 4:** Venue operating with music.
Black: Task based $L_{EX,8h}$ exceeds the Exposure Limit Value. **Grey:** Hearing protection should be worn when L_{Aeq} exceeds 85 dBA.
* observed carrying out glass disposal during task.

Table 5.5: Task L_{Aeq} and $L_{EX,8h}$ for the main tasks carried out by the bartenders in venues that had an area between 300-500m^2

		Club B		Club C		Club D		Club H	
		D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)
Day 1	$L_{EX,8h}$	**89.4**	**90.6**	**87.8**	**87.4**	**94.1**	-	**89.5**	**89.2**
	Task 1	84.5 for 0.5h	85.6 for 0.5h	-	-	-	-	-	-
	Task 2	83 for 2h	88.4 for 2h	84.1 for 2.5h	85.5 for 1h	82 for 1h	-	-	-
	Task 3	89.8 for 0.5h	85.9 for 0.5h	84.3 for 0.5h	87.5 for 0.5h	84.9 for 0.5h	-	-	75.5 for 0.5h
	Task 4	93 for 3h	93.9 for 3h	91.3 for 3h	91 for 3h	98.3 for 3h	-	93.8 for 3h	93.4 for 3h
Day 2	$L_{EX,8h}$	-	-	-	-	**84.0**	**86.7**	**84.2**	**86.4**
	Task 1	-	-	-	-	-	-	-	-
	Task 2	-	-	-	-	-	-	-	65 for 1h
	Task 3	-	-	-	-	72.5 for 1.5h	69.9 for 1.5h	68 for 0.5h	74.2 for 0.5h
	Task 4	-	-	-	-	88.2 for 3h	90.9 for 3h	88.5 for 3h	90.6 for 3h
Day 3	$L_{EX,8h}$	-	-	-	-	**91.9**	**91.7**	**96.2**	**94.0**
	Task 1	-	-	-	-	-	-	-	-
	Task 2	-	-	-	-	-	88.2 for 1h	83 for 1h	77.8 for 1h
	Task 3	-	-	-	-	88.9 for 0.5h	88 for 0.5h	83.1 for 0.5h	82.5 for 0.5h
	Task 4	-	-	-	-	96 for 3h	95.6 for 3h	100.4 for 3h	98.2 for 3h

Key: Task 1: Before music begins in venue. **Task 2:** Stocktaking **Task3:** DJ sound check **Task 4:** Venue operating with music.
Black: Task based $L_{EX,8h}$ exceeds the Exposure Limit Value.
Grey: Hearing protection should be worn when L_{Aeq} exceeds 85 dBA.

Table 5.6: Task L_{Aeq} and $L_{EX,8h}$ for the main tasks carried out by the bartenders in venues that had an area between 300-500m^2 (Cont.)

		Club J		Club L		Club M		DB 3	
		D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)	D1 (dBA)	D2 (dBA)
Day 1	$L_{EX,8h}$	**98.3**	**94.1**	**92.1**	**89.3**	**96.9**	**97.8**	**87.9**	**83.1**
	Task 1	-	-	-	-	-	-	73.5 for 3.5h	73.5 for 3.5h
	Task 2	94.3* for 1.25h	87.7 for 1.25h	79.2 for 0.5h	76.6 for 0.5h	89.3 for 2h	93.9 for 2h	88.9 for 2h	82.5 for 2h
	Task 3	99 for 0.5h	95.4 for 0.5h	96.1*for0.5h	88 for 0.5h	95.3 for 0.5h	92 for 0.5h	88.8 for 0.5h	85.1 for 0.5h
	Task 4	101.9 for 3h	97.8 for 3h	95.6 for 3h	93.3 for 3h	100.8 for 3h	101.5 for 3h	89.9 for 3h	85.4 for 3h
Day 2	$L_{EX,8h}$	**94.5**	**93.6**	**95.4**	**96.6**	**97.2**	**84.2**	-	-
	Task 1	-	-	-	-	-	-	-	-
	Task 2	-	-	90 for 0.5h	96 for 0.5h	89.5 for 2h	83.7 for 2h	-	-
	Task 3	91.7 for 0.5h	90.2 for 0.5h	97.9 for 0.5h	99.8 for 0.5h	97.3 for 0.5h	85.5 for 0.5h	-	-
	Task 4	98.6 for 3h	97.7 for 3h	99.1 for 3h	100 for 3h	101 for 3h	86.9 for 3h	-	-
Day 3	$L_{EX,8h}$	**86.7**	-	**96.1**	**97.4**	**90.1**	**87.0**	-	-
	Task 1	-	-	-	-	-	-	-	-
	Task 2	86.3 for 0.25h	-	95.6 for 0.5h	98 for 0.5h	84.8 for 2h	82.2 for 2h	-	-
	Task 3	85.2 for 0.5h	-	98.3 for 0.5h	100.2 for 0.5h	91.3 for 0.5h	87.5 for 0.5h	-	-
	Task 4	90.6 for 3h	-	99.6 for 3h	100.8 for 3h	93.6 for 3h	90.5 for 3h	-	-

Key: Task 1: Before music begins in venue. **Task 2:** Stocktaking **Task3:** DJ sound check **Task 4:** Venue operating with music.
Black: Task based $L_{EX,\,8h}$ exceeds the Exposure Limit Value. **Grey:** Hearing protection should be worn when L_{Aeq} exceeds 85 dBA.
* observed carrying out glass disposal during task.

Table 5.7: Task L_{Aeq} and $L_{EX,8h}$ for the main tasks carried out by the bartenders in venues that had an area between 300-500m^2 (DB 6/DB 7) and venues that had an area greater than 500m^2 (Club E and Club F)

		DB 6		DB 7		Club E		Club F	
		D1 (dBA)	**D2 (dBA)**	**D1 (dBA)**	**D2 (dBA)**	**D1 (dBA)**	**D2 (dBA)**	**D1 (dBA)**	**D2 (dBA)**
Day 1	**$L_{EX,8h}$**	**91.9**	**90.6**	**97.1**	**97.4**	**92.5**	**93.4**	**93.5**	**95.9**
	Task 1	70 for 3h	-	74.6 for 3.5h	69.8 for 3.5h	-	-	-	-
	Task 2	87.1 for 2h	-	88.3 for 2h	85.1 for 2h	82.1 for 2h	85.2 for 0.5h	88 for 1h	98.4***** for 1.5h
	Task 3	72.1 for 0.5h	-	97.7 for 0.5h	99.2 for 0.5h	90.7 for 0.5h	92.3 for 0.5h	83.8 for 0.5h	87.7 for 0.5h
	Task 4	95.8 for 3h	94.9 for 3h	100.9 for 3h	101.2 for 3h	96.5 for 3h	97.4 for 3h	97.6 for 3h	98.3 for 3h
Day 2	**$L_{EX,8h}$**	**89**	**89.3**	**90.4**	**95.3**	**93.0**	**95.1**	**93.2**	**-**
	Task 1	70 for 3h	70 for 3h	72.8 for 3.5h	83.5 for 3.5h	-	-	-	-
	Task 2	86.5 for 2h	86.4 for 2h	89.3 for 2h	94.9 for 2h	77.6 for 0.25h	77.9 for 0.25h	82.5 for 1h	-
	Task 3	90.9 for 0.5h	90.2 for 0.5h	91.2 for 0.5h	96.7 for 0.5h	93.5 for 0.5h	93.4 for 0.5h	86.8 for 0.5h	-
	Task 4	92.1 for 3h	92.5 for 3h	93.2 for 3h	97.8 for 3h	96.9 for 3h	99.2 for 3h	97.4 for 3h	-
Day 3	**$L_{EX,8h}$**	**93**	**94.2**	**83.5**	**83.2**	**92.2**	**95.7**	**91.6**	**91.7**
	Task 1	70 for 3h	70 for 3h	60 for 3.5h	60.8 for 3.5h	-	-	-	-
	Task 2	89.3 for 2h	90.7 for 2h	63.7 for 2h	63.8 for 2h	75.3 for 0.25h	70.5 for 0.25h	72.8 for 0.5h	73.4 for 0.5h
	Task 3	93 for 0.5h	93.8 for 0.5h	83.9 for 0.5h	83.5 for 0.5h	87 for 0.5h	92.1 for 0.5h	82.3 for 0.5h	82.5 for 0.5h
	Task 4	96.5 for 3h	97.6 for 3h	87.4 for 3h	87.1 for 3h	96.4 for 3h	99.8 for 3h	95.8 for 3h	95.9 for 3h

Key: Task 1: Before music begins in venue. **Task 2:** Stocktaking **Task3:** DJ sound check **Task 4:** Venue operating with music.
Black: Task based $L_{EX,8h}$ exceeds the Exposure Limit Value. **Grey:** Hearing protection should be worn when L_{Aeq} exceeds 85 dBA.***** observed carrying out glass disposal during task.

Table 5.8: Task L_{Aeq} and $L_{EX,8h}$ for the main tasks carried out by the bartenders in venues that had an area greater than 500m^2

		Club I		Club K		DB 2		DB 5	
		D1 (dBA)	**D2 (dBA)**	**D1 (dBA)**	**D2 (dBA)**	**D1 (dBA)**	**D2 (dBA)**	**D1 (dBA)**	**D2 (dBA)**
Day 1	**$L_{EX,8h}$**	**87.3**	**89.3**	**94.6**	**93.6**	**87.9**	**90.0**	**90.6**	**89.9**
	Task 1	-	-	-	-	73.6 for 3.5h	73.6 for 3.5h	84.3 for 3.5h	81.6for 3.5h
	Task 2	-	-	97.7 for 0.5h	98 for 0.5h	81.1 for 1.5h	85.2 for 1.5h	87.2 for 2h	87.1 for 2h
	Task 3	90.4 for 0.25h	78.1 for 0.25h	98.6 for 0.5h	97.4 for 0.5h	88.7 for 1h	88.4 for 1h	89.8 for 0.5h	87.6 for 0.5h
	Task 4	91.5 for 3h	93.5 for 3h	97.4 for 3h	96.2 for 3h	91.2 for 3h	93.5 for 3h	93.5 for 3h	93.0 for 3h
Day 2	**$L_{EX,8h}$**	**90.7**	**91.0**	-	**90**	-	-	**92.5**	**88.3**
	Task 1	-	-	-	-	-	-	89.4 for 3.5h	86.3 for 3.5h
	Task 2	-	-	-	-	-	-	85.4 for 2h	87 for 2h
	Task 3	77.5 for 0.25h	74.2 for 0.25h	-	94.8 for 0.5h	-	-	87.9 for 0.5h	81.6 for 0.5h
	Task 4	95 for 3h	95.3 for 3h	-	93.4 for 3h	-	-	95.3 for 3h	89.7 for 3h
Day 3	**$L_{EX,8h}$**	**88.6**	**88.2**	**93.1**	**91.6**	-	-	**93.6**	-
	Task 1	-	-	-	-	-	-	87 for 3.5h	-
	Task 2	-	-	93.7 for 0.5h	-	-	-	88.6 for 2h	-
	Task 3	74.8 for 0.25h	75.7 for 0.25h	92.6 for 0.5h	85.7 for 0.5h	-	-	92.5 for 0.5h	-
	Task 4	92.9 for 3h	92.5 for 3h	96.8 for 3h	95.8 for 3h	-	-	96.7 for 3h	-

Key: Task 1: Before music begins in venue. **Task 2:** Stocktaking **Task3:** DJ sound check **Task 4:** Venue operating with music.
Black: Task based $L_{EX,\ 8h}$ exceeds the Exposure Limit Value. **Grey:** Hearing protection should be worn when L_{Aeq} exceeds 85 dBA.

5.2.6 *Calculation of bartender weekly* $\overline{L}_{EX,\,8h}$

The bartenders $\overline{L}_{EX,8h,}$ was calculated for an average working week of 3 work shifts in each venue using the highest mean $L_{EX,8h}$ for 2 days and the lowest mean $L_{EX,8h}$ for 1 day in the 15 venues that were revisited. Table 5.9 and Table 5.10 summarise the $\overline{L}_{EX,8h}$ for each venue.

Table 5.9: Nightclub bartenders' weekly noise exposure levels ($\overline{L}_{EX,\,8h,}$)

	Typical number of evenings open per week	$\overline{L}_{EX,8h,}$ dBA (SD) Based on 3 days	Music Type Played
Club A	4	95.3 (0.2)	Pop/R&B
Club D	3	90.4 (1.4)	All genres
Club E	3	91.5 (1.6)	Pop/R&B
Club F	4	91.7 (1.4)	Pop/R&B
Club H	2	91.3 (1.4)	Pop/R&B
Club I	5	88.0 (0.3)	All genres
Club J	3	92.5 (2.8)	Pop/R&B
Club K	4	90.8 (1.0)	Pop/R&B
Club L	6	93.3 (0.1)	Pop/R&B
Club M	4	93.7 (0.2)	Pop/R&B
Mean	**3.8**	**91.9**	
SD	**1.1**	**1.9**	

Nightclub bartenders were found to have an $\overline{L}_{EX,\,8h,}$ between 88.0-95.3 dBA. Discobar bartenders were found to have an $\overline{L}_{EX,\,8h,}$ between 87.7-93.4 dBA. The mean $\overline{L}_{EX,\,8h,}$ in nightclubs was 91.9 dBA (SD 3.8) and 89.9 dBA (SD 2.2) in discobars. The $\overline{L}_{EX,\ 8h,}$ calculation did not reduce the bartenders' noise exposure below the exposure limit value of 87 dBA.

Table 5.10: Discobar bartenders' weekly noise exposure levels ($\overline{L}_{EX,\ 8h,}$)

	Typical number of evenings open per week	$\overline{L}_{EX,8h,}$ dBA (SD) Based on 3 days	Music Type Played
DB 1	5	87.7 (1.2)	Dance/Rave
DB 4	3	88.2 (0.5)	Pop/R&B
DB 5	4	90.1 (2.4)	Pop/R&B
DB 6	3	90.3 (0.8)	Pop/R&B
DB 7	7	93.4 (0.2)	Pop/R&B
Mean	**4.4**	**89.9**	
SD	**1.7**	**2.2**	

5.2.7 Calculation of other venue employees daily noise exposure $L_{EX,\ 8h}$

The $L_{EX,\ 8h}$ of other venue employees was estimated using the data gathered from the mobile SLM measurements. In total the $L_{EX,\ 8h}$ was estimated for 157 employees in the subgroup of 15 venues who permitted more 3 nights noise monitoring (see Chapter 2, section 2.3.6.1). As shown in Figure 5.10, DJs and security personnel located inside nightclub venues had a mean $L_{EX,\ 8h}$ higher than 90 dBA. The DJs in discobars also had a mean $L_{EX,\ 8h}$ higher than 90 dBA. Nightclubs employees in each role had a higher mean $L_{EX,8h}$ than discobar employees. However an independent T-test only showed a significant difference between the $L_{EX,8h}$ for security personnel inside the venue (p < 0.01). None of the discobar venues had a cash desk or cloakroom.

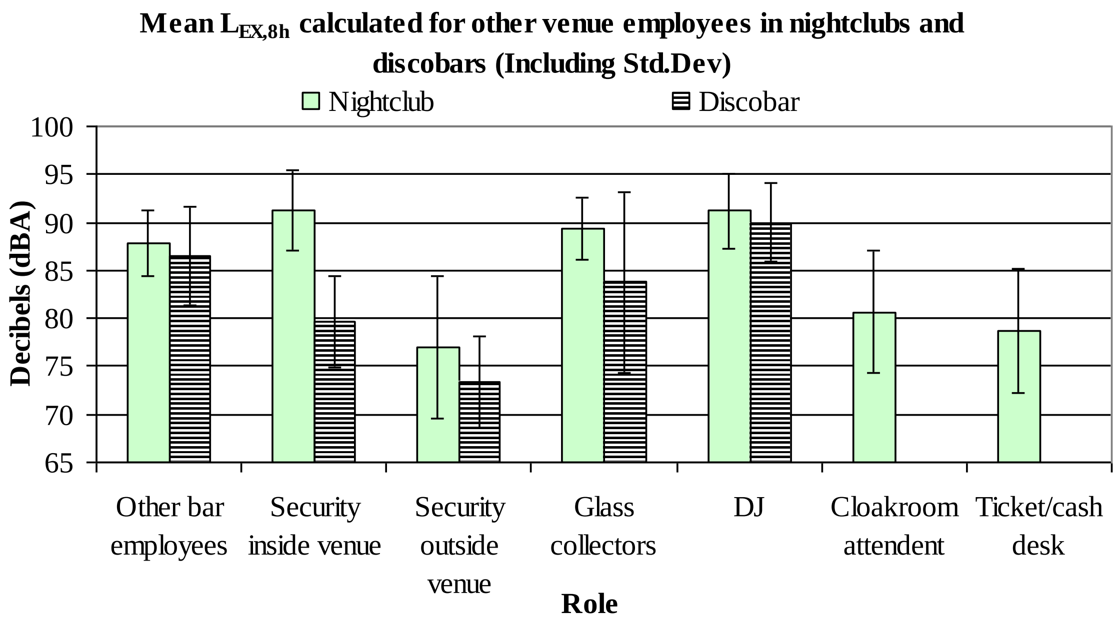


Figure 5.10: Bar chart illustrating mean $L_{EX,\ 8h}$ calculated for other venue employees in nightclubs and discobars

5.2.7.1 Employee inter-personal $L_{EX,\ 8h}$ variability

Revisits and re-monitoring were conducted in 15 venues. ANOVA analysis was used to assess whether there was a significant difference between the calculated $L_{EX,8h}$s on the initial measurement and subsequent revisits. None of the measurement nights were significantly different based on the employees' roles ($p > 0.05$).

5.2.8 Calculation of other venue employees weekly $\overline{L}_{EX,\ 8h}$

The weekly exposure of other venue employees was calculated over a 3 day week in each of the 15 venues revisited. As shown in Figure 5.11, the majority (63%) of employees had a weekly noise exposure below the exposure limit value 87 dBA. The glass collectors, DJs and security inside the venue exceeded 87 dBA most often.

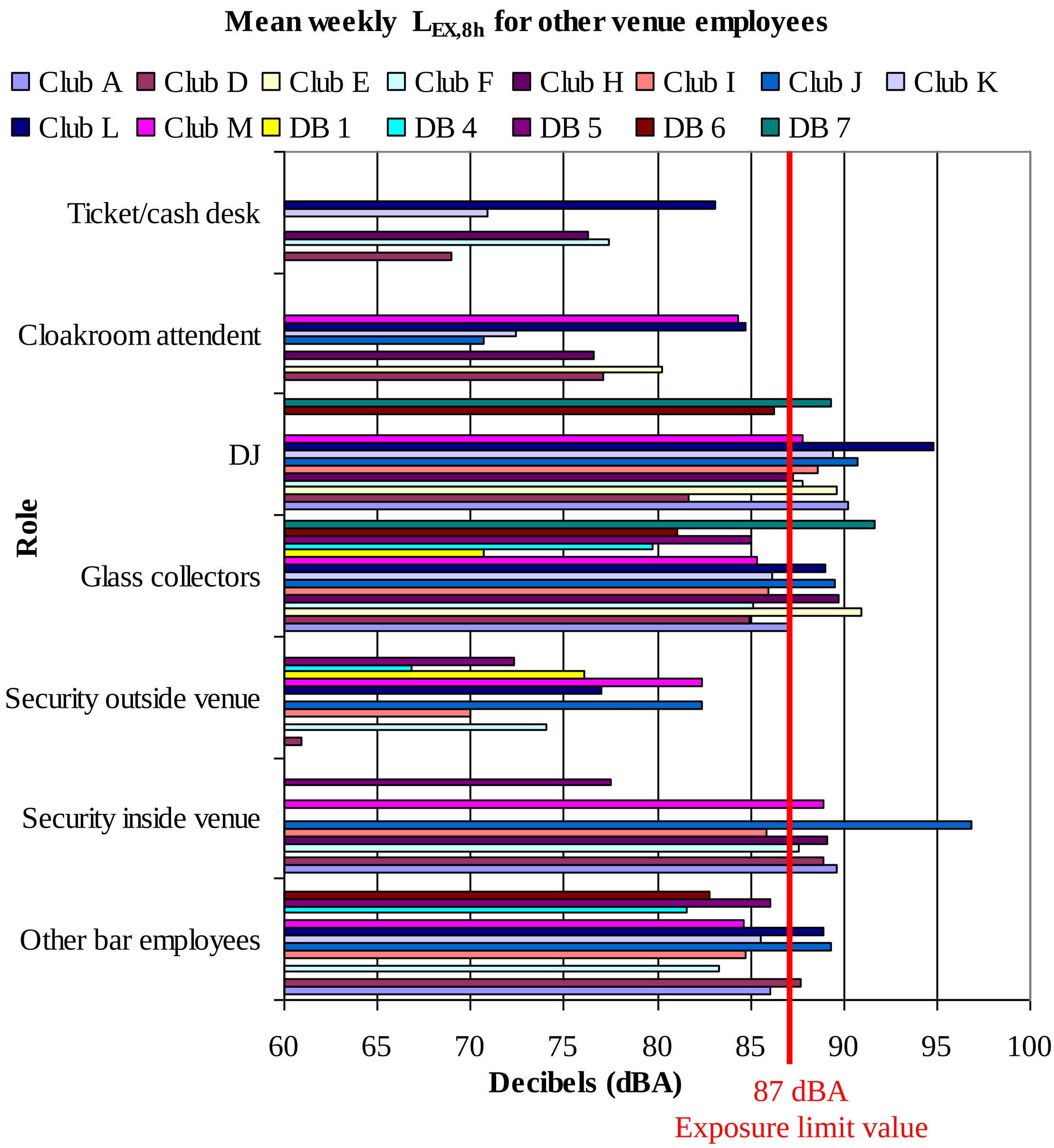


Figure 5.11: Weekly noise exposure of other venue employees in nightclubs and discobars. Calculations were based on a typical three day week using the employees mean $L_{EX,\,8h}$

5.2.9 Estimation of bartenders L_{EX8h} based on ISO 9612 Engineering method

In section 5.2.5, the estimation of $L_{EX,\,8h}$ was based on the L_{Aeq} of the tasks carried out by the bartenders and the total time spent at each task (hereinafter Task $L_{EX,8h}$). This was the method adopted by all previous researchers to measure employees' noise exposure. To estimate the risk of hearing loss to bartenders (see section 5.3.1) the daily noise exposure of bartenders ($L_{EX,8h}$) was based on the engineering method, as per ISO

9612 (hereinafter Engineering $L_{EX,8h}$). This engineering method was applied to the noise levels collated in the subgroup of 15 venues, where 3 nights of dosimeter noise monitoring took place. In total, 85 Engineering $L_{EX,8h}$ values were analysed.

The typical range of the Task $L_{EX, 8h}$ (for the subgroup n = 15) was between 71.4 dBA to 98.4 dBA. The range of the Engineering $L_{EX, 8h}$ was slightly wider at 66.7 dBA to 99.4 dBA. The mean difference between the Task $L_{EX, 8h}$ and Engineering $L_{EX, 8h}$ was only 0.2 dBA and there was no significant mean difference between the mean $L_{EX, 8h}$ values ($p < 0.05$). As shown in Figure 5.12 below, the mean Engineering $L_{EX,8h}$ was significantly different in nightclub and discobar venues, with nightclub bartenders being exposed to a mean Engineering $L_{EX,8h}$ 2.7 dBA higher than in discobar venues (p = 0.028). The mean calculated expanded uncertainty of the Engineering $L_{EX, 8h}$ was included in Figure 5.12.

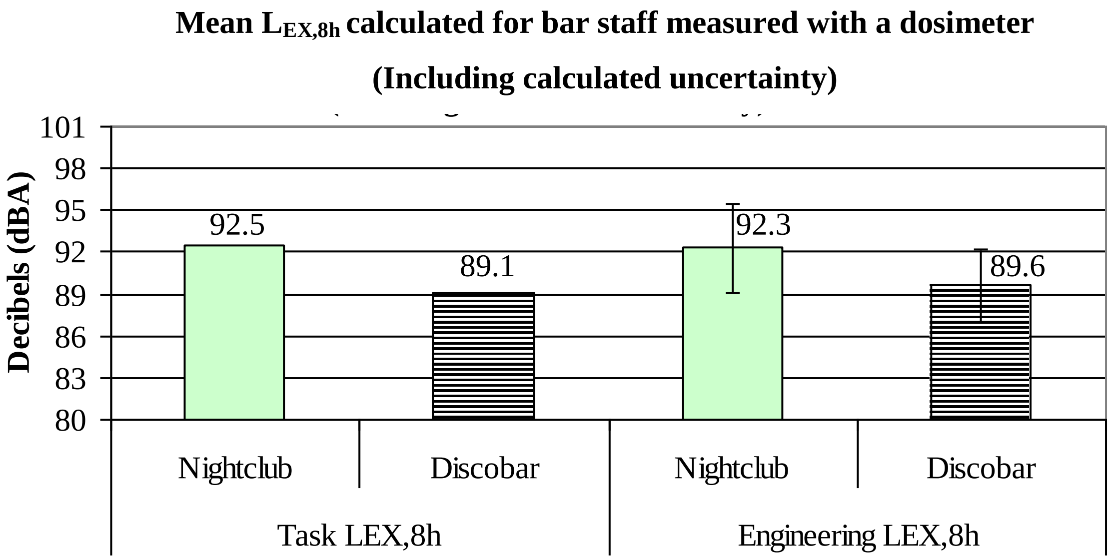


Figure 5.12: Comparison of mean $L_{EX, 8h}$ based on task based or engineering methods for nightclubs and discobar venues (includes expanded uncertainty bars)

The arithmetic Engineering $L_{EX, 8h}$ means are presented in Table 5.11 along with the mean expanded uncertainty estimate for each of the 15 revisited venues. Club A was the loudest nightclub (96.3 dBA) while DB 6 was the loudest discobar venue (92.5 dBA). The overall uncertainty for nightclubs was 3.16 and 2.60 for discobar venues. Independent T-tests proved the difference in uncertainty between nightclub and discobar venues was significant ($p < 0.01$).

Table 5.11: Number of measurements of the average $L_{EX,\ 8h}$ for each venue studied

Venue	N	Mean $L_{EX,8h}$	Mean uncertainty	Venue	N	Mean $L_{EX,8h}$	Mean uncertainty
Club A	6	96.3 dBA	2.77	**DB 1**	6	83.6 dBA	2.75
Club D	5	88.6 dBA	3.82	**DB 4**	6	89.0 dBA	2.65
Club E	6	93.6 dBA	3.55	**DB 5**	5	91.6 dBA	2.28
Club F	5	94.2 dBA	3.10	**DB 6**	6	92.5 dBA	2.68
Club H	6	89.4 dBA	3.65	**DB 7**	6	91.6 dBA	2.57
Club I	6	88.9 dBA	4.20	**Total:**	29	89.6	2.60
Club J	5	92.0 dBA	2.94				
Club K	5	92.7 dBA	3.08				
Club L	6	95.1 dBA	2.67				
Club M	6	91.6 dBA	2.62				
Total:	56	92.3	3.16				

5.3 Risk assessment – Risk characterisation and effects

This section summarises the results from 2 different methods adopted to conduct the risk characterisation/effects of the noise analysis:

- Data generated from hazard identification and hazard characterisation were used to predict the effect of daily noise exposure and duration of employment could have on hearing of bartenders working in the bar area closest to the dance-floor.

- Self administered tinnitus history questionnaires were completed by employees to indicate those who had experienced tinnitus.

Data will be presented separately for nightclub and discobar employees due to the significant differences in their noise exposures during work (see section 5.2).

5.3.1 ISO 1999:1990 Calculation results

The $L_{EX,\ 8h}$ mean for bartenders and mean age and years in industry was utilised to predict the bartenders Hearing Threshold Level associated with Age and Noise (HTLAN). The worst case HTLAN scenario for bartenders was also estimated using the oldest bartender, in both nightclubs and discobars.

5.3.1.1 Calculation for HTLAN employees

This mean calculation was based on the mean Engineering $L_{EX,\ 8h}$, for bartenders located in the bar area closest to the dance-floor in the venue (see Table 5.11 in section 5.2.9). The mean and worse case values inputted into the HTLAN calculation are summarised in Table 5.12.

Table 5.12: Mean age and $L_{EX,\ 8h}$ for venue bartenders used to calculate HTLAN

	Nightclub	**Predicted % of hearing loss**	**Discobar**	**Predicted % of hearing loss**
Mean exposure bartenders:				
Bartender $L_{EX,8h}$:	92.3 dBA	1%	89.6 dBA	1%
Bartenders exposure:	5 years		7 years	
Bartenders age:	24 years		27 years	
Worse case exposure bartenders:				
Bartenders $L_{EX,8h}$:	96.3 dBA	18%	92.5 dBA	9%
Bartenders exposure:	25 years		25 years	
Bartenders age:	40 years		42 years	

An independent T-test was conducted between the mean HTLAN and worst case HTLAN of males and females, but no significant difference was found due to gender for either scenario ($p > 0.05$). Nightclub and discobar venues were not significantly different in HTLAN for mean or worst case scenarios ($p > 0.05$). The HTLAN based on the worst case scenario for bartenders ranged from 9% to 18%.

5.3.2 Tinnitus history questionnaire for all employees

None of the venues had sent an employee for a diagnostic hearing test or had conducted hearing checks on their employees prior to their employment in the venues. However, nearly half of the employees had their hearing professionally tested (34/80). Of these, 5 had this carried out with previous employers while the remaining went for the test of their own volition. The employee noise questionnaires revealed that only 34% of the employees would wear hearing protection if it was provided by management**.** A chi-squared test for independence identified a significant association between the employees who had previously had hearing tests and those who would be more likely to wear hearing protection if provided by management, $\chi^2(4, n= 80) = 13.2$, $p = 0.01$, $phi = 0.41$.

5.3.2.1 Prevalence of tinnitus in venue employees

Two in 5 employees had experienced a hearing related problem in the past. Of these the following symptoms were felt: ringing or buzzing in the ears by 58% (18/31), trouble hearing by 45% (14/31), ear disease by 42% (13/31) and dizziness at 10% (3/31). The employees were quizzed about their knowledge of what factors might have caused the hearing problems. Nearly half of the employees (49%) reported that excessive music and loud noise caused the hearing problem, as shown in Figure 5.13.

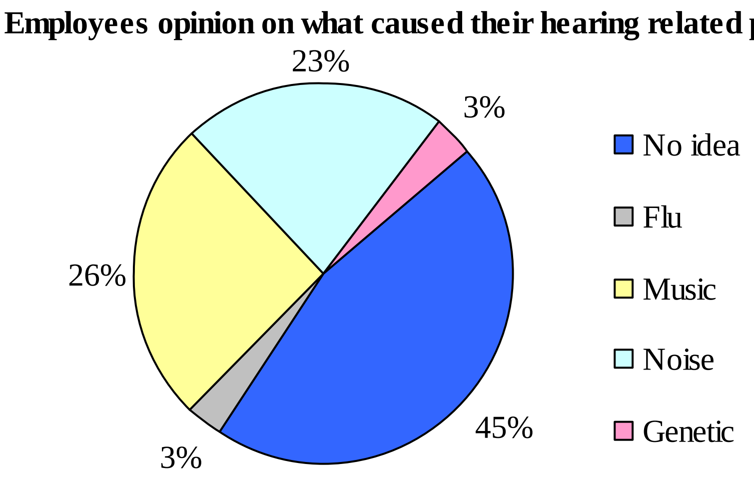


Figure 5.13: The employees opinion on what, to their knowledge, caused their hearing related problem

Very few (14%) employees experienced ringing in their ears having used MP3 players. More employees reported experiencing ringing in their ears after going to concerts (49%) or other music bars or nightclubs (45%) than in their own nightclub (38%). A significant association was determined between experiencing ringing in the ears at other nightclub venues and experiencing ringing in the ears in the venue they work in, χ^2 (1, n =77) = 9.1, p = 0.005, *phi* = 0.34.

5.4 Chapter summary

Noise risk assessments were used in this research to quantitatively explore the daily and weekly noise exposure of bar employees in Leinster. In total 13 nightclubs and 7 discobar venues participated in the research (response rate = 16%). During the noise risk assessment stage of the fieldwork over 380 hours of noise monitoring took place using sound level meters and dosimeters in 20 venues.

The analysis of the noise risk assessment results split the venues into two categories (nightclubs and discobars) since nightclubs were significantly louder than discobars (p < 0.05). The mean nightclub bartenders' daily noise exposure ($L_{EX,\ 8h}$) was 92 dBA, almost four times more than the accepted legal limit. Discobar bartenders mean $L_{EX,\ 8h}$ was 89.1 dBA. Other venue employees such as the DJs and security personnel located inside the nightclubs had a mean $L_{EX,\ 8h}$ higher than 90 dBA. A quarter of bartenders were exposed to L_{Cpeak} levels above 140 dBC.

The Hearing Threshold Level associated with Age and Noise (HTLAN) for bartenders was estimated, based on the mean daily noise exposure ($L_{EX,8h}$) of bartenders and the number of years bartenders worked in the industry. An independent T-test was conducted between the mean HTLAN and worst case HTLAN of males and females, but no significant difference was found due to gender for either scenario ($p > 0.05$). The HTLAN based on the worst case scenario for bartenders ranged from 9% to 18%.

Chapter 8 will discuss the main findings from the noise risk assessment results.

Chapter 6

RESULTS

Noise Risk Management

6.0 Introduction

This noise management results chapter will be laid out in 2 sections: (i) consideration of noise control options and (ii) selection and implementation of noise controls.

6.1 Risk management – Noise control options available

The following section considers internal and external control options available to satisfy the risk management of noise in the nightclub/discobar industry. The internal control measures were based on the requirements of the Noise Regulations, 2007 and adherence to the noise control measures outlined in the Health and Safety Authority (HSA) "Noise of Music" guidance document. Enforcement officers' opinions were used as an external control measure to assess the challenges faced in enforcing the occupational noise legislation in venues.

6.1.1 Venue compliance with Noise Regulations, 2007

The task $L_{EX,\ 8h}$ data, as presented in Chapter 5, section 5.2.5.2, were compared to the lower and upper exposure action values defined in the Noise Regulations 2007 (80 dBA and 85 dBA respectively). It is apparent from Table 6.1 that only 6.1% of bartenders $L_{EX,8h}$ measurements in discobars and none of bartenders $L_{EX,8h}$ measurements in nightclubs were below the lower exposure action value of 80 dBA. The majority of bartenders $L_{EX,8h}$ measurements in discobars and nightclubs exceeded the exposure limit value (87 dBA).

Chi-squared tests for independence indicated no significant difference between bartenders $L_{EX,8h}$ measurements in discobars and those in nightclubs when it came to compliance with the exposure action values or exposure limit value, χ^2 (3, n=95) = 7.2, $p > 0.05$, phi= 0.28.

Table 6.1: The percentage of bartenders $L_{EX,8h}$ measurements in the bar closest to the dance-floor who exceeded the exposure action values and exposure limit value (n = 95)

Noise Regulations, 2007 exposure action and limit values	Nightclub n = 62	Discobar n = 33
Below the lower exposure action value (< 80 dBA)	0%	6.1%
Between the lower and upper exposure action values (80-84.9 dBA)	4.8%	15.2%
Between the upper exposure action value and the exposure limit value (85-86.9 dBA)	4.8%	2.9%
Above the exposure limit value (> 87 dBA)	90.4%	75.8%

Bartenders $L_{EX,8h}$ measurements located in the bar areas closer to the dance-floor of nightclubs and discobars exceeded the exposure limit value more frequently (90% and 76% respectively) than bartenders $L_{EX,8h}$ measurements located in other bars in the nightclub and discobar venues (68% and 50% respectively), as shown in Figure 6.1.

Security personnel inside nightclub venues were often located near the dance-floor area close to the DJ and it may be for this reason that they were the group to have the highest percentage exceeding the exposure limit value (87 dBA). Employees located outside the main section of the venues, for example cloakroom attendants, ticket/cash desk or outside security, were all below the lower exposure action value (80 dBA).

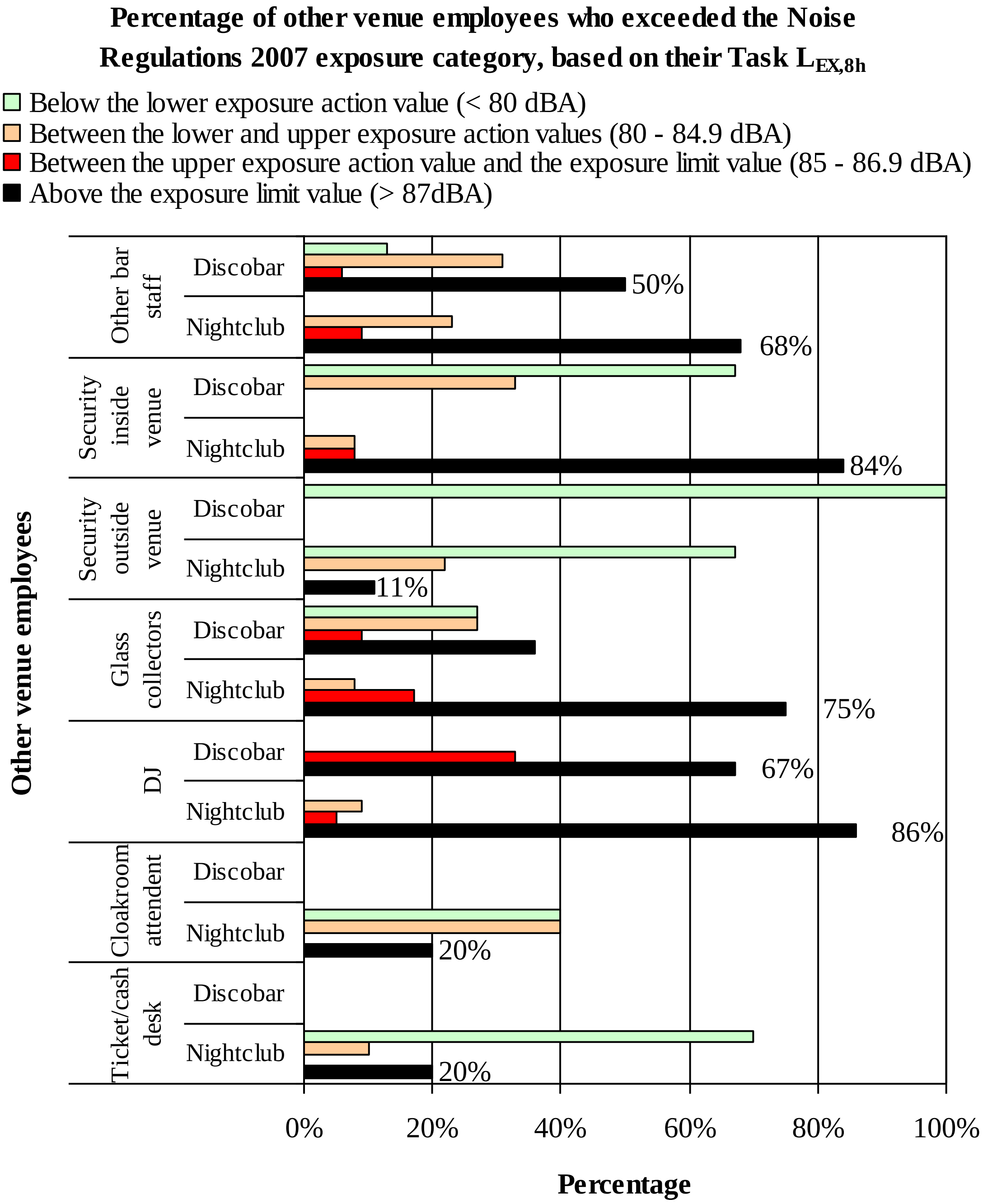


Figure 6.1: The percentage of other venue employees in nightclubs and discobars who exceeded the exposure action values and exposure limit value

6.1.1.1 Venue compliance with the requirements of exposure action values

The Noise Regulations, 2007, stipulate that at the lower (80 dBA) and upper exposure (85 dBA) action values certain control measures must be put in place. Table 6.2 highlights the level of compliance of the 20 venues with the control measures when the lower and upper exposure action values were exceeded. Compliance was based on the recommendations of the HSA "Noise of Music" document and will be addressed in more detail in Section 6.1.1.2.

Table 6.2: Compliance with the Noise Regulations, 2007: lower and upper exposure action value requirements (n = 20)

When task $L_{EX,8h}$ was greater than 80 dBA				
Had a noise risk assessment.	**Had a safety statement.**	**Had carried out health surveillance.**	**Had hearing protection available to any employee who requested it.**	**Had provided noise information to all employees.**
10%	**75%**	**0%**	**20%**	**5%**
When task $L_{EX,8h}$ was greater than 85 dBA				
Had noise control measures in venue.	**Had hearing protection signs in place.**	**Had barriers in place.**	**Hearing protection was provided and worn by all employees**	**Had employee hearing checks carried out by a registered practitioner?**
See section 6.1.1.2	**0%**	**0%**	**5%**	**0%**

Only Club F had a safety statement available to view by the researcher even though 75% of venues indicated that they had a safety statement. The safety statement in Club

F did not mention noise as a hazard and was out of date in citing the General Application Regulations of 1993 rather than the updated version of 2007. None of the venues had hearing protection signs in place in any of the staff areas.

6.1.1.2 Noise Regulations, 2007 compliance assessment

Twenty amplified music venues participated in the Noise Regulations, 2007 compliance assessment. All venues were assessed using the legal requirements of the Noise Regulations, 2007 and were scored based on the scoring methodology outlined in Chapter 3, section 3.1.1.3.

The total scores for compliance with the Noise Regulations, 2007 ranged between 20 and 340 out of a possible 620 marks. Figure 6.2 illustrates the total percentage compliance calculated for the venues. Club F, Club I and Club M had the highest percentages of compliance. There was a significant difference in the compliance percentage for nightclubs (M = 22.2, SD = 16.3) and discobars (M = 11.3, SD = 4.6; t (20) = 2.36, p = 0.039, two-tailed).

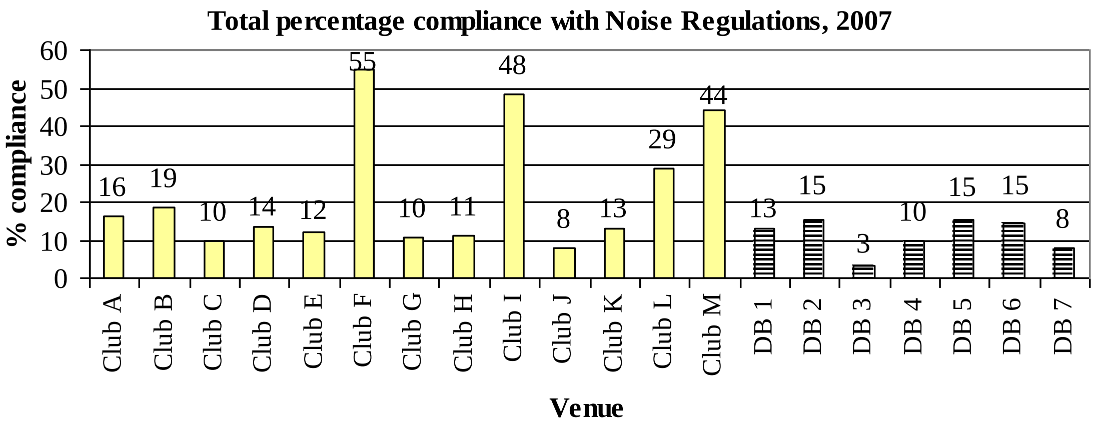


Figure 6.2: Calculated total percentage compliance for each venue

The remainder of the compliance assessment results are presented based on each of the 6 headings used to measure compliance with the Noise Regulation, 2007.

1. Noise survey:

Club F and Club M were the only venues to have had noise risk assessments carried out. In Club M, the noise risk assessment was not available to view as it was not held onsite. The noise risk assessment in Club F was carried out by an environmental consultant who completed the noise measurements between 00:30-02:00 on a Saturday night in 2008 using a calibrated Type 1 sound level meter (SLM). Only 1 measurement was taken in each employee location and was used to estimate the employees $L_{EX, 8h}$. While it was established that hearing protection needed to be worn by employees in the nightclub, no advice was provided about suitable hearing protection. No octave band analysis was conducted by the consultant.

2. Noise control measures:

The score for noise control measures, as summarised in Figure 6.3, were based on the data collected from the venue manager interview and observation of venue design features, as outlined in Chapter 3, sections 3.1.1.1 and 3.1.1.2 respectively. None of the venues had all of the features recommended by the guidance document (HSA "Noise of Music"). However, many of the venues had a combination of control measures in place. The scores for compliance with the noise control measures ranged from 20 to 120.

Two nightclubs had the highest percentages adherence with the guidance document, while discobar venues had lower compliance percentages overall. An independent T-test showed there was a no significant difference in the scores for nightclubs (M = 81.9, SD = 24.8) and discobars (M = 70.0, SD = 28.1; t (20) = 0.980, p = 0.34, two-tailed).

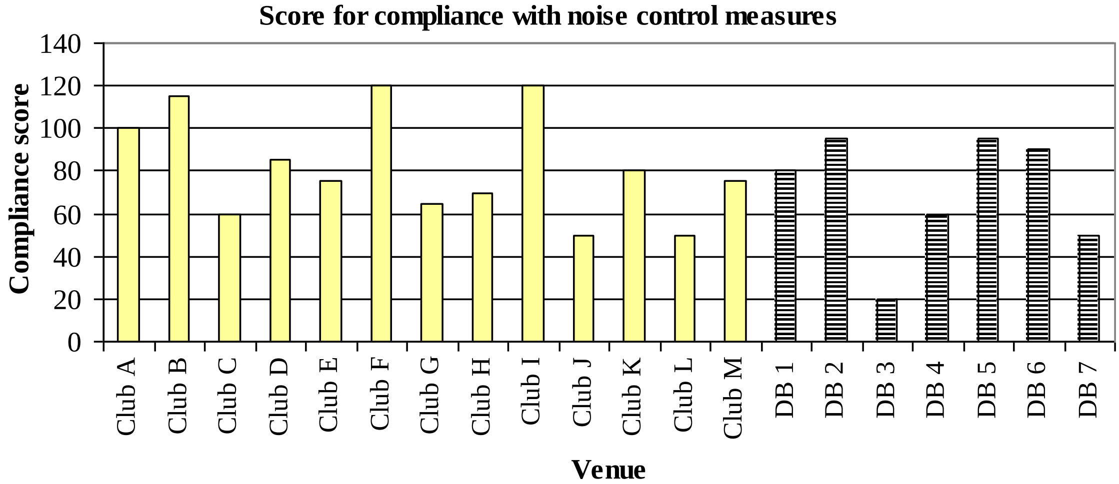


Figure 6.3: Score for noise control measures compliance for each venue (maximum score 150)

None of the venues played the sound system at its maximum volume. Six nightclubs and 1 discobar had a sound limiter in place that did not permit the volume to be raised to the maximum output level. Controllable sound zone areas were utilised in 50% of the venues.

While none of the venues rotated bar staff to quieter areas e.g. cloakrooms, there was rotation of glass collectors to cloakroom duties in Club F and Club I. The employees spent approximately 2 hours in the cloakroom and were then swapped to spend a further 1.5 – 2 hours collecting glasses in the venue.

<u>3. Training and instruction:</u>

Noise awareness training for employees was only delivered in 1 venue, Club M. This was carried out by the Health and Safety officer for the venue. No documentation was available detailing the content of the training and the manager was unable to answer any questions in relation to the length of time the training took.

4. Audiometric testing:

Audiometric testing was not completed by any of the venue management, as result the score for audiometric compliance was zero for all 20 venues.

5. Personal hearing protection:

Hearing protection was made available in 4 nightclub venues. In Club F, the hearing protection had been selected by a consultant, in Club I and Club L the hearing protection was selected by the manager, while in Club M the Health and Safety officer selected the hearing protection. The employees in Club I were consulted about hearing protection comfort when they were trained in how to insert the hearing protection at induction.

Club I was the only venue where management insisted that staff wore hearing protection at all times in the nightclub. The other venue managers left the wearing of hearing protection to the discretion of their employee. For these reasons Club I scored highest in personal hearing protection compliance. In Club L the employees working in the dance-floor area were observed wearing hearing protection. In neither Club F nor Club M did employees wear the hearing protection made available by management.

6. Noise management:

Both Club F and Club M had a full-time Health and Safety officer for their venue. Neither had attended specific training courses on noise measurement; hence it was deemed that they only partially met the criteria for being suitably trained in conducting noise measurements. While no health and safety professional was employed in Club I and Club L, the management partially met the management criteria by ensuring employees had new hearing protection available to them at all times.

Club D was the only venue to be inspected by the HSA. Noise was reportedly not assessed during the inspection. Club F had been contacted by the HSA in 2008 requesting a report on the nightclubs noise levels. This report was prepared by the manager using SLM spot checks in the nightclub.

6.1.2 External control measures - enforcement officers opinions

A 10-item questionnaire was made available via the internet to the Environmental Health Officers (EHO) in Northern Ireland (NI) responsible for enforcing the equivalent of the Irish Noise Regulations, 2007. Sixty EHOs were contacted and 34 local authority/local government EHOs completed the survey (response rate = 57%). Please refer to Appendix 7 for a copy of the enforcement officers' questionnaire.

Three-quarters (26/34) of the EHO respondents had more than 5 years experience working in noise enforcement, however only 32% (11/34) held a formal qualification specifically in the area of noise measurement. In 2010, 68% of the respondents had attended a "Sound Advice" noise training session specifically focused on noise enforcement in the entertainment sector, facilitated by the Chief Environmental Health Officers Group NI (CEHOG).

6.1.2.1 Current compliance of amplified music venues with the Noise Regulations (UK)

The revised Control of Noise at Work Regulations (Northern Ireland) 2006 (hereinafter NI Noise Regulations) was enforceable since April 2008 in nightclubs/pub venues and was directly comparable to the Noise Regulations, 2007. The EHOs measured compliance through the following methods:

1. Interviewed management to establish employee work patterns (63%).

2. Examined the noise risk assessment document for reference to daily noise exposure, exposure action values, exposure limit values and control measures (59%).
3. Inspected the implementation of control measures in the venue (48%).
4. Reviewed complaints made against the venue related to noise (48%).
5. Interviewed staff about their hearing protection usage (44%).
6. Took noise measurements in the venue during operating hours using a sound level meter or dosimeter (44%).
7. Reviewed suitability of hearing protection provided (22%).
8. Determined whether there was suitable Hearing Protection Zone signage in the venue (19%).
9. Carried out a document audit including examination of training and audiometric files (7%).

Table 6.3 summarises the responses of the EHOs who responded to the question

"In the nightclub/pub venues in your enforcement area how would you rate the following?"

While the management were aware of the requirements of the NI Noise Regulations (64%), compliance with the requirements was not met or only partially met by the majority of venues. In the venues that did have a noise risk assessment (18%) only half adhered to the control measures recommended in the risk assessment (9%). The provision of hearing protection, designation of hearing protection zones and audiometric testing were the main legal requirements that were not met by venues.

Table 6.3: EHO opinion of venues awareness of and compliance with the requirements of the NI Noise Regulations (n = 34)

Awareness and requirements	Not met	Partially met	Fully met
Managements knowledge of the requirements of the NI Noise Regulations	27%	64%	9%
Noise risk assessment supplied by venue management	50%	32%	18%
Adherence with the control measures outlined in the noise risk assessment	32%	59%	9%
Hearing protection worn by employees where needed	48%	38%	14%
Use of suitable hearing protection signage where needed	67%	24%	10%
Audiometric hearing tests provided to venue employees where needed	81%	10%	10%
Noise training provided to venue employees where needed	67%	29%	5%

Improvement notices had been served by 6 of the EHOs specifically in relation to the legal requirements of the NI Noise Regulations. Only in 1 case did the EHO indicate that the improvement notice had not been complied with and in that case the venue was prosecuted for non-compliance. As per Figure 6.4, 4 EHOs specified that improvement had been made to noise control measures most often, for example staff rotation, facing speakers away from bar areas or installing a sound limiter device. Risk assessments were requested in 3 of the improvement notices served along with suitable hearing protection. Lowering the noise levels and providing noise training or audiometric testing were only requested in 1 improvement notice.

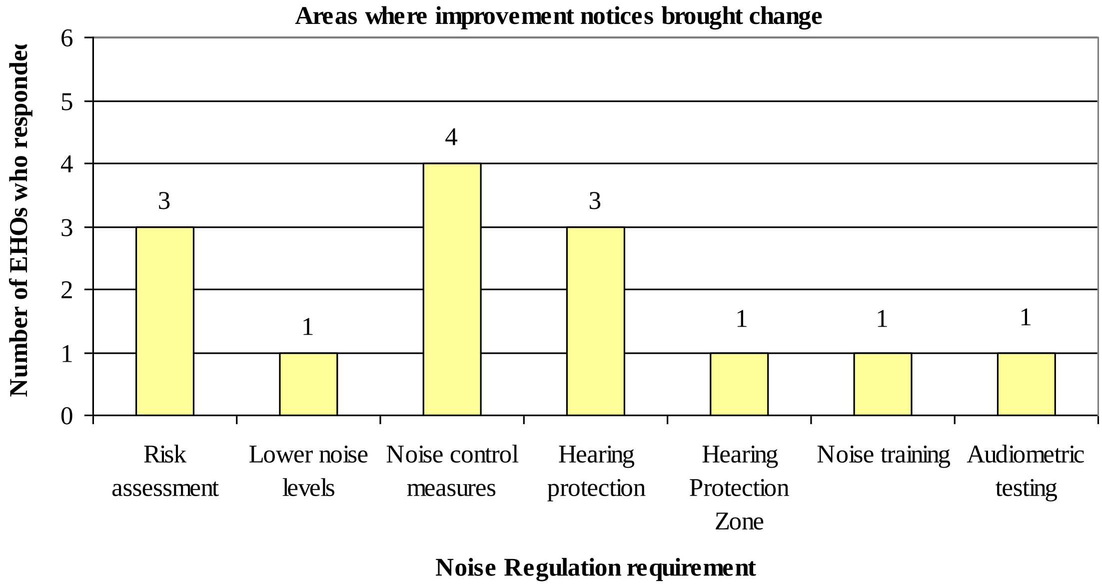


Figure 6.4: Areas where improvement notices were effective in enhancing compliance with the NI Noise Regulations.

6.1.2.2 Noise related initiatives EHO departments participated in

Less than 40% (12/34) of EHOs had participated in a noise related initiative in their department, with varied levels of success. Three types of initiatives were conducted, namely raising awareness of the legislation and its requirements, requesting formal risk assessments from the venues and finally conducting inspections of the venues within the EHOs' district. One third of noise initiatives were to simply send information to the managers of music venues to raise their awareness of their legal requirements in relation to noise exposure. During the questionnaire none of the EHOs indicated whether these information initiatives were successful.

Formal risk assessments were requested in 42% (5/12) of the noise initiatives. The EHOs found that there was a limited response to the request for noise risk assessments either due to the economic climate or a lack of qualified noise consultants in Northern Ireland. One EHO used improvement notices to obtain noise risk assessments *"eventually"* from the venues, another EHO stated that the request for risk assessments was often not followed up until the next routine inspection.

Three of the noise initiatives involved physical inspections of the venues by the EHOs. Noise measurements were taken in a variety of locations in the venues and risk assessments were requested where appropriate. Improvement notices were served to ensure noise risk assessments were produced. The 3 EHOs described their physical inspection initiatives as a complete success.

One EHO described an initiative that involved all 3 elements described above,

"*Questionnaires were sent out to entertainment premises to determine their level of awareness and compliance. Follow up visits were carried out in premises that didn't respond or provided inadequate information to assess compliance. It was a successful awareness raising initiative."*

6.1.2.3 Challenges faced by EHOs

Figure 6.5 summarises the challenges EHOs faced when enforcing the NI Noise Regulations. Monetary constraints were highlighted as the greatest challenges faced by the EHOs, namely budget constraints, the reduction in enforcement officers, cost of out of hours work and noise enforcement not being a top priority. Lack of experience with noise equipment, hearing protection and control measures were also among the challenges faced by the enforcement officers.

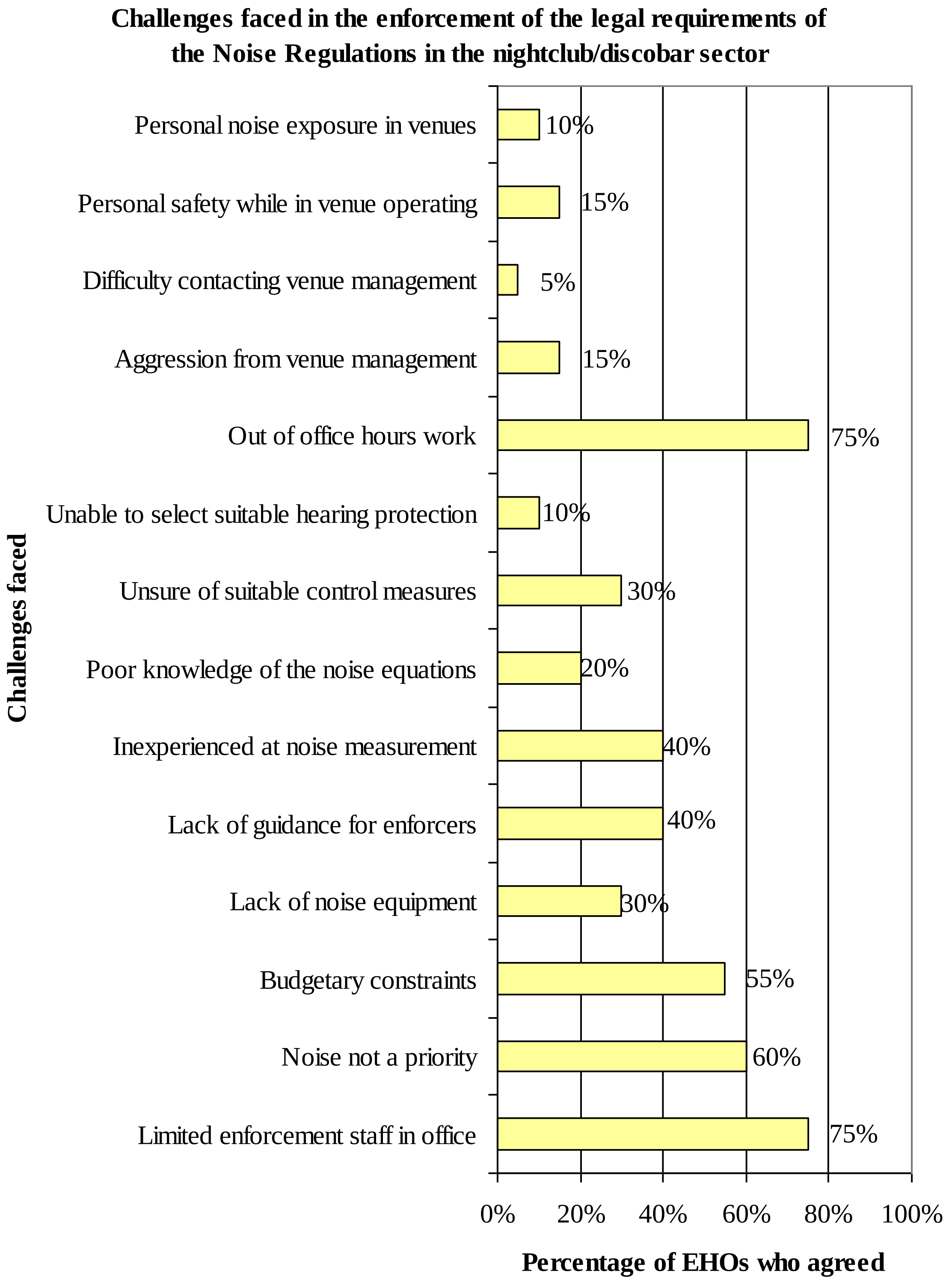


Figure 6.5: Challenges faced by EHOs when enforcing the NI Noise Regulations

6.1.2.4 Suggested actions to improve enforcement/compliance

All enforcement officers felt that noise risk assessments and noise awareness training were essential requirements of the NI Noise Regulations. Training was highlighted as the highest ranked action to improve the enforcement of the NI Noise Regulations. As shown in Table 6.4, guidance and training for enforcement officers on suitable noise control measures and the development of noise awareness training aimed at venue managers were options selected by 86% of EHO respondents to improve compliance.

Supporting venue managers to become complaint with the legislation was a preferred method over legal enforcement and fines. Half of the enforcement officers (48%) agreed that objecting to late night operating licences based on non-compliance with the NI Noise Regulations was a more effective method to improve the enforcement of the legislation than improvement and enforcement notices.

Table 6.4: EHOs enforcement options to improve compliance with the NI Noise Regulations (n =34)

Positive reaction to suggested enforcement options	
More information on the legislative requirements provided to venue managers.	76%
Increase guidance from enforcers on suitable noise control measures.	86%
Additional noise monitoring by enforcers.	52%
Increase demand for suitable risk assessments by enforcers.	57%
Develop noise awareness training aimed at venue managers.	86%
More enforcement notices issued to venues.	29%
More follow ups on enforcement notices.	33%
Increased serving of improvement notices on venues.	33%
Objections to late night operating licenses being renewed based on non-compliance with the NI Noise Regulations.	48%
Unannounced noise spot checks carried out by enforcers.	67%
Comment on suitable design features for new nightclub/pub venue fit-outs.	52%

One EHO expanded on their opinion of enforcement actions to improve compliance, they felt there was a need for *"more prescriptive regulations"* specifically providing guidance on the engineering methods to adopt to design out *"excessive noise levels"*. A

"Lack of knowledge of engineering solutions led venue operators to immediately jump to using earplugs which demonstrates a lack of understanding of noise control".

Training for management was selected by all responding EHOs as an action music venues could take to improve their compliance with the NI Noise Regulations. They did not feel strongly that the training of employees should be conducted by an external trainer (24%). EHOs also felt that management engaging with inspectors and monitoring noise levels in the venue would improve compliance (76% and 71% respectively).

6.1.2.5 Additional comments from enforcement officers

An open ended question at the end of the questionnaire invited additional comments. Five enforcement officers responded. The NI Noise Regulations were identified as causing difficulties for the venues by 3 EHOs. Specifically an EHO observed that the lowering of the action levels made compliance with the legal noise levels difficult:

"The lowering of the action levels has meant that background noise from pub goers has implications for venue operators under the Noise at Work Regulations i.e. even where there is no amplified music being played, this is ludicrous! Can you tell clientele to quieten down so as you don't breach Noise at Work Regulations? The point is that the Noise at Work Regulations may not be specific enough to deal with noise in entertainment venues."

One EHO felt the entertainment industry was identified as already being *"over regulated"*. A reduction in the number of entertainment venues was an effect of the *"over regulation"* of venues. Another EHO felt that there were a *"small number"* of entertainment venues where noise was *"an issue"*. The *"large turnover of casual and waiting staff"* was also a challenge faced by the venue management. Finally, further specific information for enforcement officers was acknowledged as necessary

"More information on sound limiting technology available and design of venues would be useful."

6.2 Risk management – Selection of controls

Octave band data was analysed to aid the selection suitable hearing protection. Each noise risk assessment completed for venue managers included a section on suitable hearing protection based on the results presented below.

6.2.1 Hearing protection selection

It was imperative to ensure the hearing protection did not over or under protect the employee. Five types of hearing protection were assessed for their suitability in venues. The worst case octave band data from each venue was used to calculate A-weighted sound pressure level (L'_A) when using the hearing protectors (see Chapter 3, section 3.2.1.1).

An independent sample T-test was conducted to evaluate the differences between the protection provided by each type of earplug in all nightclub and discobar venues. Table 6.5 lists the 5 types of earplugs, the mean protection value when wearing the hearing protection in nightclubs and discobars and the calculated p value. In all cases, there was a significant difference between the mean hearing protection levels afforded in nightclubs and discobars ($p < 0.05$).

Table 6.5: Mean hearing protection provided by 5 hearing protectors in venues

Type of earplug	Nightclub mean hearing protection (SD)	Discobar mean hearing protection (SD)	*p* value
Howard Leight Max	74.2 dBA (3.8)	68.3 dBA (5.2)	*0.008*
Howard Leight Smart	81.2 dBA (3.8)	75.1 dBA (5.1)	*0.008*
Flents Seal rite plugs	74.2 dBA (3.8)	68.0 dBA (5.5)	*0.009*
EAR Classic earplugs	60.8 dBA (2.7)	55.3 dBA (5.1)	*0.005*
Elvex gel pods banded	79.4 dBA (3.7)	73.4 dBA (5.7)	*0.011*

According to British Standard (BS) 458:2004, if a hearing protector has a protection value that reduces the noise level reaching the ear to 70 - 85 dBA, it is classified as good or acceptable (please refer to Chapter 3, section 3.2.1.1 for the methodology used to calculate the protection value). The mean hearing protection offered by 4 of the earplugs examined suited the nightclub noise levels. However, the EAR classic hearing protection, supplied to employees in Club F and Club L, overprotected the employees in nightclubs.

It is clear from Figure 6.6 that hearing protection is not a one fits all solution. The Howard Leight Max and Flents Seal rite were the most suitable hearing protection for the majority of the nightclub venues (62%) while the Howard Leight Smart (86%) and Elvex gel pods (71%) were the most suitable hearing protection in discobar venues.

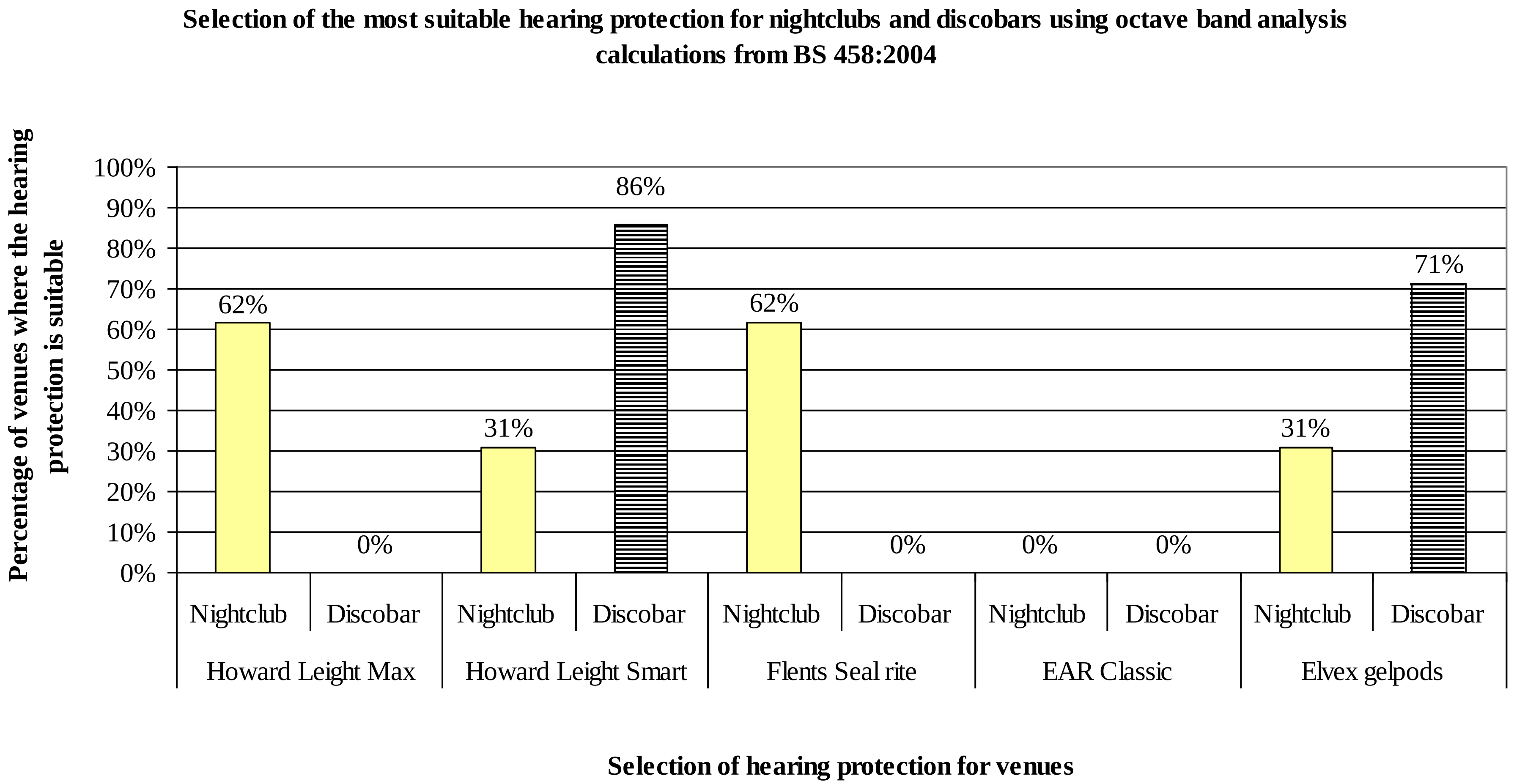


Figure 6.6: Bar chart presenting the most suitable hearing protection for nightclub and discobar venues based on BS 458:2004 calculations

6.3 Chapter summary

This chapter showed the findings from an exploration of the internal and external control options available to satisfy the risk management of noise in the nightclub/discobar industry. None of the venues examined were fully compliant with the requirements of the 2007 Noise Regulations.

While 75% of venues had a safety statement only 10% venues had a noise risk assessment. EHOs in Northern Ireland also found that managements' knowledge of the requirements of the legislation was not acceptable, and that half of the venues were not supplying noise risk assessments.

For the EHOs surveyed supporting venue managers to become complaint with the legislation was a preferred method over legal enforcement and fines. Enforcement officers agreed that objecting to late night operating licences was a more effective method to improve the enforcement of the legislation than improvement and enforcement notices.

The mean hearing protection offered by 4 of the earplugs examined suited the nightclub noise levels. However, the EAR classic hearing protection, supplied to employees in 2 venues, overprotected the employees. In one venue, employees did wear suitable hearing protection. It is clear from Figure 6.6 that hearing protection is not a one fits all solution.

Chapter 8 will discuss the main findings from the noise risk management results.

Chapter 7

RESULTS

Noise Risk Communication

7.0 Introduction to risk communication results chapter

There were a variety of noise risk communication methods applied during this study (Chapter 4). The goal of this aspect of noise risk communication was to develop and deliver a sector specific noise awareness training programme and conduct a pilot study to assess the effectiveness of such training. This chapter will present the noise risk communication findings.

Section 7.1 will outline the interactive exchange of information and opinions gathered from venue managers and employees. This was achieved through the use of structured interviews, noise questionnaires and focus groups.

Section 7.2 will examine whether there was an increase in employee knowledge and a positive change in health belief/attitudes following the delivery of the noise awareness training.

Section 7.3 will measure the intermediate outcomes from the noise awareness training. It will also present the safety culture findings in the participating venues (Club A, Club I and DB 5).

7.1 Interactive exchange of information and opinions

In total 18 managers (80% response rate) and 80 venue employees (16% response rate) completed noise interviews and noise questionnaires at the beginning of this study. The objective was to examine their attitudes to and knowledge of the Noise Regulations, 2007 and its application in the nightclub/discobar industry. After analysing the interview and questionnaire data, 5 focus groups were used to develop effective noise awareness training and to identify the narrative that was most likely to lead to desired beliefs and behaviours.

7.1.1 Management interviews

The managers were most commonly male (78%), in the age category 25-40 years old (67%), while 2 were younger than 25 and 4 were more than 40 years old. The mean length of time in a management role in the venue was 6 years (SD 7.9) with a mean of 15.8 years (SD 8.5) total experience working in the amplified music industry.

None of the managers had been trained in noise or its risks in their workplace. The most common workplace training course completed by managers was manual handling (72%) followed by first aid (56%) and Hazard Analysis Critical Control Point (HACCP, 44%).

7.1.1.1 Mangers knowledge of their Noise Regulations, 2007 responsibilities

Two-thirds (12/18) of nightclub managers correctly identified hearing loss as an effect that repeated loud noise exposure might have on an individuals health. Only 5 of the managers were aware that sounds measuring over 75 dBA had the potential to damage human hearing.

While 72% (13/18) of the managers were aware that occupational noise legislation existed in Ireland, none were able to identify the relevant legislation. One manager was aware that the revised legislation was applicable since 2008 in venues. Knowledge of the noise exposure action values and exposure limit values was extremely poor. None of the 18 managers knew the decibel level at which hearing surveillance should be made available to staff (lower exposure action value -80 dBA) when hearing tests are to be conducted (upper exposure action value – 85 dBA) or the exposure limit value (87 dBA). One manager was aware of the noise level above which hearing protection *must* be worn by employees (85 dBA).

7.1.1.2 Managers attitudes to noise control in the industry

Two thirds of managers were aware of sound limiter devices (12/18). The 6 managers who were unaware of these devices were informed during the interview that:

"A sound limiter is a device that can be attached to the main power supply of an amplification unit in the venue. If the music level exceeds a preset sound level a light may flash to warn the operator to turn down the volume. If the warning light was ignored the music would be automatically cut off from the power source."

Managers who did not have a sound limiter installed made more negative comments about sound limiters than those who did have sound limiters in their venues. Five managers expressed concern for the potential to damage equipment from the cut out of the sound. One nightclub manager was under the impression that sound limiter settings automatically meant that the noise exposure experienced by his employees was in compliance with legislation. Another manager was aware that the sound limiter device set the limit on the volume of the music through the loudspeakers but was not in compliance with the noise exposure levels set in the Noise Regulations, 2007. Five of the managers felt that having a sound limiter was a good idea since it was a means to control the DJs sound levels.

During the structured interview the nightclub managers were asked;

"If the maximum decibel level was exceeded in the nightclub what would you do to reduce the noise level?"

They were then given 5 options based on the control measures in the Health and Safety Authority (HSA) "Noise of Music" guidance document and they were asked to rank them from Grade 1-5 in order of importance. If the managers had chosen the hierarchy of control measures suggested by the HSA then hearing protection would have been the last control measure selected. The provision of personal protective equipment (PPE) was selected as the second control measure they would put in place even though it is a last resort according to the HSAs control measure hierarchy. Turning the music volume down was the first control measure that they chose (elimination). The managers were least likely to redecorate the nightclub with absorbent materials even though this is the second most preferred control measure recommended by the HSA.

Only 3 managers indicated that they felt noise was one of the 5 most important issues a venue deals with. Environmental noise was mentioned as often as occupational noise exposure. More than half of the managers (10/18) responded to customers' requests to alter the music volume by personally carrying out a listening check to assess whether a change in music volume was required.

7.1.1.3 Managers attitudes to noise legislation changes in the industry

Managers recognised that venues were generally noisier for staff than other industries. However, this was regarded as the accepted norm or *"par for the course"*. Interestingly, 4 of the managers mentioned that the DJs who controlled the music levels had bad hearing.

The main challenge faced by the industry was striking a balance between compliance with the legislation and maintaining the atmosphere the customers expected from the venue. Culturally, loud music was identified as an essential feature in the industry and managers thought that employees would resist the use of hearing protection. Two managers felt that noise legislation was something which should be enforced by the HSA *"across the board"* in entertainment venues, including discobars. Another manager observed that noise exposure, like the effect of smoking, only became apparent after years of exposure.

7.1.1.4 Managers commitment to protecting employees hearing

The managers were fearful of the noise legislation requirements regarding hearing testing since they felt that disgruntled ex-employees might take legal action.

Club M was the only venue that had previously conducted noise awareness training with employees. However, when questioned, the manager indicated that there were no details available on the content of the training or the method of delivery used. More than 75% (14/18) of venue managers thought it would be beneficial if employees were trained about noise exposure and its effects. They generally felt that increasing knowledge and awareness in their employees would help them to enforce the use of hearing protection. Two nightclub managers felt that by training their employees there might be more cause to sue or take a legal case against the employer for noise exposure.

7.1.2 Noise questionnaire for employees

The knowledge gaps identified from analysis of the noise questionnaire, completed by 80 employees in the 17 venues, are presented below (response rate = 16%). The demographic data was detailed previously (see Chapter 5, section 5.1.2.1).

7.1.2.1 Employees knowledge of Noise Regulations, 2007 requirements

Only 10 of the employees were aware that there was occupational noise legislation which prohibits the noise levels which an employee can be exposed to. As a result, only 1 employee knew the decibel levels at which hearing protection should have been made available to staff *i.e.* 80 dBA. Furthermore, none of the nightclub employees knew the noise level at which hearing protection *must* be worn or the exposure decibel level that an employee should not be exposed to over an 8-hour working day.

More than one fifth of employees (18/80) thought their venue had a noise risk assessment. Interestingly, in the 2 venues that actually reported having a noise risk assessment, Club F and Club K, none of the employees in Club F were aware of the noise risk assessment and in Club K only one of the employees who completed the questionnaire was aware there was a noise risk assessment completed.

7.1.2.2 Employees experience of noise in their workplace

Only 59% (47/80) of employees responded to the question:

"What is your experience of noise in the workplace?"

Figure 7.1 indicates the responses given. Nearly half of the responses (46%) highlighted a lack of volume control in the venues. Customers were described as being unhappy if the noise level was lowered (15%). Other comments were that noise levels were loud but staff felt this was to be expected (13%) and that live bands were particularly loud (6%).

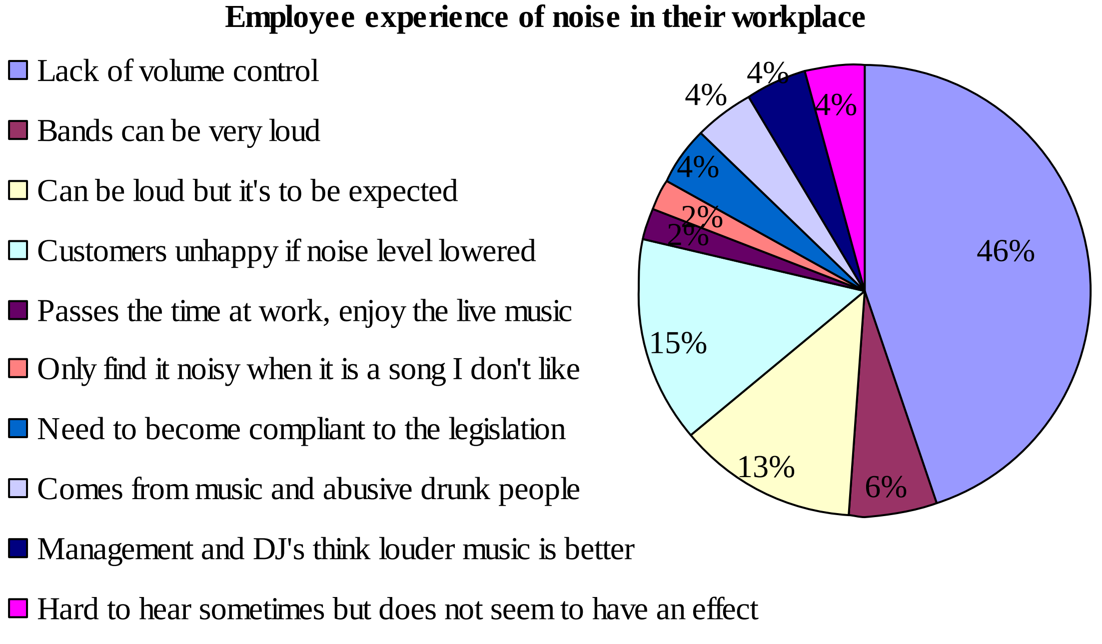


Figure 7.1: Pie-chart illustrating the employees' experience of noise in their workplace.

Employees felt that noise levels should be checked more often and that if noise was harmful to hearing then something must be done to prevent this happening.

7.1.2.3 Employees knowledge of the effects of excessive noise in their workplace

Twenty percent of employees were correct when they suggested that sound levels over 75 dBA could be damaging to human hearing. Slightly more employees thought that sound over 100 dBA could be damaging (27.5%). Two employees thought sounds over 1000 dBA were damaging while the remaining 50% (40/80) did not know. When employees were asked if they felt that loud music had an effect on hearing, most (65/80) felt excessive noise would have a harmful effect. The others either felt it had a beneficial effect on hearing (7/80) or no effect at all (6/80).

7.1.2.4 Employee attitudes to wearing hearing protection

Hearing protection had been worn in the past by 41% (33/80) of the employees who completed these questionnaires. The majority wore hearing protection during industrial employment (29%) *e.g.* in construction or manufacturing jobs. Only 3 employees disagreed with the notion that wearing suitable hearing protection saved them from damage. A third of employees (27/80) would wear hearing protection if it was made mandatory by their employers.

An inability to hear alarms or customers was cited by 74% (29/39) of the employees as the reason why they would not wear hearing protection. As summarised in Figure 7.2 the other reasons for not wearing hearing protection were: concerns that it would be uncomfortable to wear (8%) or that noise did not bother the employees (5%). Those who responded positively to hearing protection felt it would protect their hearing and prevent future deafness. The employees in Club I, where hearing protection was mandatory, indicated that wearing hearing protection made it easier to hear customers' orders.

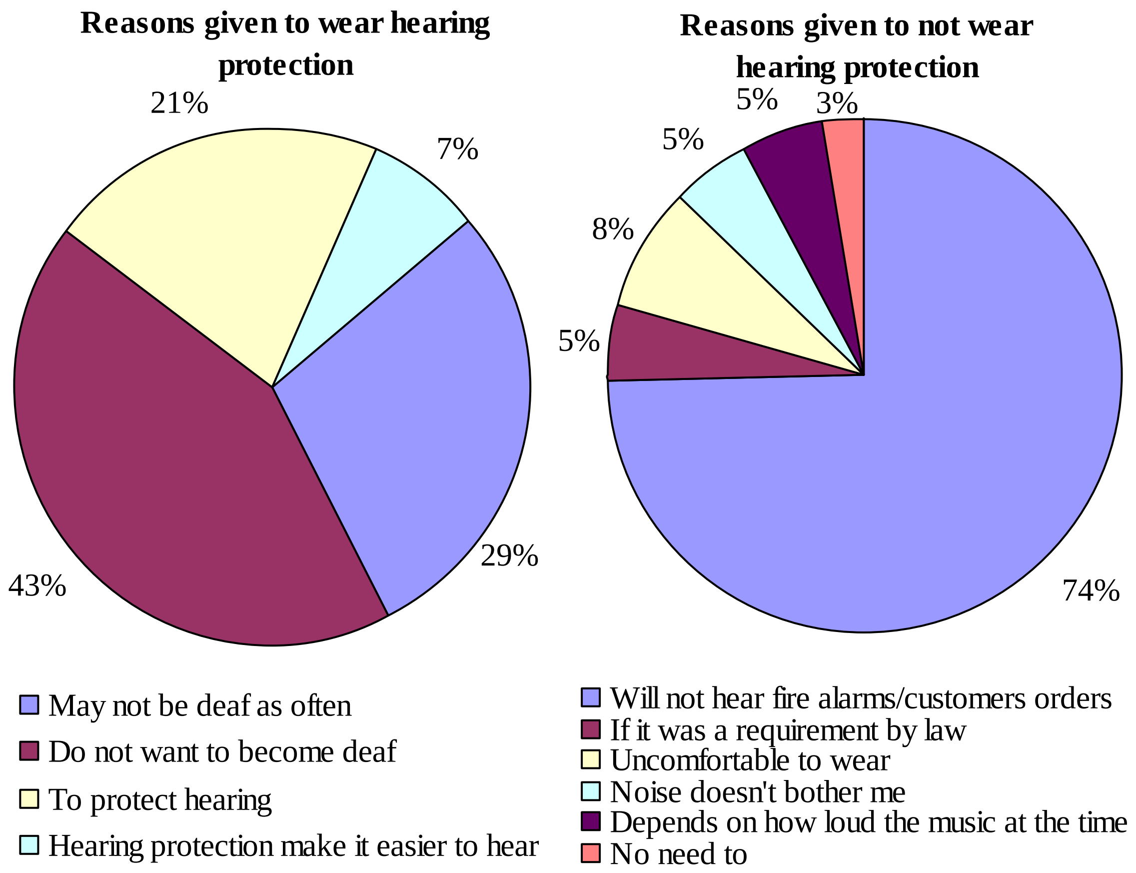


Figure 7.2: Employees' responses when asked why they would or would not wear hearing protection.

7.1.3 Focus groups studies

Following the manager interviews and employee questionnaires it was evident that there was a knowledge deficiency around the effects that working in loud music environments could have on employees hearing. Furthermore, there was an attitude from management and employees that nightclubs and discobars were expected to be loud music environments and they felt that any changes to reduce employee noise exposure might lead to a loss of customers.

Focus groups were used to help develop effective noise awareness training and to identify the narrative that was most likely to lead to desired beliefs and behaviours in the nightclub/discobar industry. The training content was designed to meet the requirements of the Noise Regulations, 2007.

The focus group findings will be presented in 6 sub-sections, one for each of the adapted HBM constructs, as follows:

1. Perceived susceptibility to noise in the workplace.
2. Perceived severity of noise exposure and its effects on quality of life.
3. Perceived barriers and benefits of hearing protection use.
4. Perceived self-efficacy to hearing protection use *i.e.* the individual's belief that they can select suitable hearing protection and insert it correctly.
5. Interpersonal influences: Co-workers and norms.
6. Situational influences: Fatalism and environmental barriers.

In each of the subsections, the adapted HBM constructs are presented in a table format. The first column of the tables summarise the focus group participants' attitudes. The second column in each table identifies the key points addressed in the training to influence employee attitudes.

7.1.3.1 Participant demographics

A total of 32 nightclub employees were engaged in structured conversation in 5 focus group discussions. Only 1 focus group was conducted in Club D. There were between 5-9 participants in each focus group. As shown in Table 7.1 demographics did not differ greatly between the groups. However, Club D participants were generally older (37.5%) than their counterparts in Club A and Club I (0%, 20% respectively). Bartenders, glass collectors, cash desk tellers, security and bar stockers were all represented. DJs did not attend the focus groups since they were regarded by management as self employed.

Table 7.1: Demographics of focus groups

	Venue	Number of participants			Percentage ages of participants		
		Total	***Male***	***Female***	***<20***	***20-29***	***>30***
Group 1	A	9	8	1	22%	78%	0%
Group 2	A	5	2	3	60%	40%	0%
Group 3	D	8	6	***2***	25%	37.5%	37.5%
Group 4	I	5	5	***0***	20%	60%	20%
Group 5	I	5	2	***3***	60%	40%	0%
Total	3	32	23	***9***	34%	53%	13%

More than two-thirds of the participants spoke English as their first language. The majority of the participants were male (72%). The age range was 18-44 years old. The mean age was 24.7 years old. Employees had worked in their nightclubs for time periods from 3 months to 8 years (M= 3.07, SD = 1.92). The range of hours worked in the nightclub was 5-50 hours (M=18.4, SD =11.4).

7.1.3.2 Perceived susceptibility to noise exposure

This construct is summarised in Table 7.2 and included participant's perceptions of their experiences of working in nightclubs and the susceptibility of the employees to hearing loss from noise exposure.

Focus group participants did not consider *their* nightclub to be loud. They also did not consider nightclubs to be loud compared to the noise of using a jackhammer. Noise was regarded as something intrusive and unwanted, whereas music was described by the majority of participants as *"a source of entertainment"*.

Table 7.2: Summary of employee attitudes and key training points addressed based on the adapted HBM construct: *Perceived susceptibility to noise in the workplace.*

Summary of employee attitudes	Key points to address during training
The participant's nightclub was not a loud work environment.	Excessive repeated exposure to noise in excess of 85 dBA could cause noise induced hearing loss (NIHL).
Music was enjoyable, not harmful	Addressed loud noise/music as an invisible danger.
Desired information on the decibel level of everyday noises	A graphical noise thermometer displayed a variety of sounds over 85 dBA that people experienced in everyday life.
Employees in different roles were unsure of their noise exposure.	Calculated daily noise exposures ($L_{EX,\ 8h}$) for each group of employees were identified and discussed (data taken from Chapter 5 Results, section 5.2.5 and 5.2.7)
Ringing in the ears was common after working in the nightclub.	Ringing in the ears was identified as *"alarm bells"* to warn that excessive noise had been experienced.

The participants identified that noise awareness training should cover the noise levels commonly experienced in life *e.g.* smoke alarms or hair dryers. Many participants did not know whether they were exposed to loud noise levels or about their susceptibility to noise.

Employee induction helped employees in Club I to recognise the damage repeated exposure to nightclub noise could have had on their health. In the other venues, ringing in the ears after work was *"normal"* and experienced by many of the participants. Since the ringing did not last, it was difficult for the participants to accept the risk of the negative outcomes from their noise exposure:

"It doesn't seem long term. You wake up fine the next day or you just get used to it."

7.1.3.3 Perceived severity of noise exposure and its effects

This construct included participant's perceptions of the effects noise in nightclubs could have on their health, summarised in Table 7.3.

Table 7.3: Summary of employee attitudes and key training points addressed based on adapted HBM construct: *Perceived severity of noise exposure and its effects.*

Summary of employee attitudes	Key points to address during training
Desired training information on how noise causes hearing damage.	Ear hair cell damage is irreparable.
Hearing loss was far off in the future.	Aging causes hair cells to break but loud noise causes more damage than aging alone.
Effects of hearing loss discussed in greater detail by Club I employees	Group discussion on the effects of NIHL.
Desired training information on what effect loud noise could have on hearing.	A Health and Safety Executive (HSE UK) noise clip simulated the effects NIHL could have during the employees' life.
Tinnitus was an effect of exposure to loud music had on a DJ.	An audio example of tinnitus was followed by a group discussion about tinnitus.
Hearing tests would be good for the industry and for the employees.	Internet based personal hearing test used to indicate participants hearing ability.

All of the participants agreed that their hearing could be at risk from working in nightclub venues. Participants wanted to know how noise affects their hearing. The participants did not appreciate their ability to influence their future hearing health. Many did not think of the effects of hearing loss and this might affect their motivation to protect their hearing.

"You don't really think about the hearing though until it is said to you".

A bartender in Club I felt that if he was working in the nightclub "*24/7*" he would be concerned over the noise. Club I participants correctly indicated that the effect of loud music depends on the length of time for which an employee was exposed to it.

"If its twice a week for a year you wouldn't be that bad but I suppose if you were working 5 nights a week for 5 or 6 years it will cause something."

Participants wanted to have training that showed them the effect exposure to loud noise might have on their hearing over the long term. In Club I, a participant indicated that he would be worried about hearing loss from music because

"I know a DJ that has tinnitus. I know he got that from DJ-ing, so I mean if he got that from DJ-ing then surely the staff can get it as well, so it's dangerous enough."

Club I participants mentioned the benefit of audiometric hearing tests to confirm if their insertion technique for the hearing protection was suitable and was preventing hearing loss. Participants wanted to know what effect noise had on their hearing. In general, participants felt that if management knew employees hearing test results then changes could be made to the noise management in the venue. It was recognised that a poor hearing test might prove that an employee had diminished hearing but were aware that it was not necessarily caused from working in the nightclub. Suggestions for how the hearing tests would be most practically applied were:

1. A hearing test at the commencement of employment in the nightclub.
2. A routine 6 month check to make sure hearing was not deteriorating.

7.1.3.4 Perceived barriers and benefits of hearing protection use

As identified in Table 7.4, many employees had preconceived notions concerning the cumbersome nature of hearing protection. Thus, many reported finding hearing protection more beneficial than they had expected. One benefit of suitable hearing protection was that it was possible to hear a customers order *more* clearly when wearing the hearing protection.

Table 7.4: Summary of employee attitudes and key training points addressed based on the HBM construct: *Perceived barriers and benefits of hearing protection use.*

Summary of employee attitudes	Key points to address during training
Surprised it was possible to hear customer when wearing hearing protection. *No ringing in the ears after wearing hearing protection in the nightclub.* *Hearing protection was an individuals control measure against noise.*	Discussion of how the use of suitable hearing protection was a means by which NIHL could be prevented.
Need for mandatory hearing protection use. *Fear of injury or ear infection from inserting hearing protection.* *Hearing protection was time consuming.*	Employee barriers identified with hearing protection were addressed.

In Club A, the management supplied hearing protection recommended by this researcher during the fieldwork stage of the project. The type chosen was based on the octave band analysis from the nightclub. Club A management permitted employees to sign a waiver if they felt they did not want to wear hearing protection. The earplugs were selected due to their ability to allow human speech to pass through while reducing background noise. Immediately after inserting hearing protection in Club A, the employees were able to hear customers clearer and the music *"faded into the background"*.

In Club I, wearing hearing protection was mandatory. The hearing protection supplied was a swimmers earplug. It was a clear gel that could be moulded and customised to fit the wearer. The employees in Club I initially found it difficult to hear speech, which was frustrating for them, as illustrated by the following comment:

"I used to hate them, because you couldn't hear an order. It's just something you have to get used to. You would be leaning in over the counter and ear to their mouth."

Wearing hearing protection in the nightclub also eradicated ringing in the ears after work. If employees had a problem with the noise levels in Club A, they felt that an individual control measure they could have used was to insert their hearing protection.

There was quite a variation in the acceptance of hearing protection, which was clearly influenced by managements engagement. Some participants indicated that they would not wear hearing protection unless it was mandatory. This was due to difficulties inserting earplugs or the uncomfortable feeling from wearing the earplugs while they were working. In Club I, the participants explained that at first they were reluctant to wear hearing protection but management persevered. In Club D, employee fears for their jobs were an inhibitory factor when it came to voicing concerns to management.

While the hearing protection in Club I was discrete some participants had reduced the size of their hearing protection too much and ended up with a piece of gel lodged in their ear canal, which needed to be removed by a doctor. In other groups, participants feared infection or injury from inserting earplugs or perceived that safe behaviour (inserting earplugs) was more time consuming than risky behaviour (not inserting earplugs).

7.1.3.5 Perceived self-efficacy to use hearing protection

This construct included participants' perceptions of their ability to use hearing protection correctly, as summarised in Table 7.5.

Table 7.5: Summary of employee attitudes and key training points addressed based on the HBM construct: *Perceived self-efficacy to use hearing devices*

Summary of employee attitudes	Key points to address during training
Live bands were very loud compared to when the DJ played music. Being able to hear speech indicated how loud the nightclub was.	Trainer demonstrated use of two suitable types of hearing protection and indicated when hearing protection should be worn.
Difficulty inserting the hearing protection, they kept falling out.	Paired groups of employees were supervised by trainer until employees were confident in their hearing insertion techniques.
Lip reading and training request.	Role play conducted with venue music playing while employees read aloud. During the role play participants wore earplugs to show that communication was possible with suitably selected hearing protection.

Knowing how to insert the hearing protection was not intuitive.

"When I first got them I didn't have a clue. I just picked it up and I was just trying to put it in. I didn't know that I had to roll it up."

Some employees were unable to master the technique of inserting hearing protection

"I put them in, but even at that they keep coming out."

In Club A and Club I, where live bands occasionally played prior to the DJs set, participants spoke about the loudness of live bands in comparison to DJs. The live bands brought their own loudspeakers and it was difficult to tolerate the noise issuing from them. The music from the DJ was more acceptable to the participants because it was produced by the nightclubs' loudspeakers. They also pointed out that the nightclub loudspeakers were generally above ear height whereas the live bands' loudspeakers were in a rig that was located at ground level. One glass collector indicated the difficulties bands created:

"When the bands are playing at all times you have to mind where the glasses are because they would fall off the tables."

Communication with customers and communication between staff was important. Participants determined if a nightclub was excessively loud or not based on whether they could communicate with each other behind the bar. Exploring the issue of communication further it emerged that bartenders were able to lip-read orders from customers and did not always hear what orders customers had placed. This lip-reading skill was not one that they had realised was helping them to communicate. Security personnel had experienced difficulties communicating with customers due to noise levels in the nightclubs.

7.1.3.6 Interpersonal influences

Table 7.6 indicates participant's perceptions of: their intention to select and use hearing protection, accepted cultural norms (that nightclubs were loud), perceptions of noise legislation and the perception that management cared for their employees welfare.

Table 7.6: Summary of employee attitudes and key training points addressed based on the HBM construct: *Interpersonal influences.*

Summary of employee attitudes	Key points to address during training
A selection of hearing protection allowed employees to choose which type was best suited to them, based on their work role.	Identified that a change of attitude towards hearing protection was necessary.
Customers expect nightclubs to be loud. Turning music down will lose customers. Attitudes of management to noise.	Identified the challenges faced to become compliant with the Noise Regulations, 2007.

One size or type of hearing protection did not suit all. Participants were interested in a variety of hearing protection during the focus groups. However, the most popular version of the hearing protection was the reusable earplug that did not require rolling to be inserted. The younger staff identified with this type of hearing protector since it was similar to headphones used with personal stereos. Security personnel in Club D felt that stalks on the earplugs could be dangerous if they were dealing with a disruptive customer, as they feared the earplug could be forced into the ear canal if they were punched in the side of the head. Security personnel's preference was for the soft expandable disposable hearing protector.

There was an acceptance that nightclubs needed to be loud since they were entertainment venues where people come in to experience *"loud music"*. Music was needed to drown out the noise of bottles being disposed and other peoples' conversations. Loss of customers was cited in many of the groups as a concern if the music volume was to be reduced in the venue. However, if the music level was too high participants felt this could lead to a loss of customers. In their own experience frequenting nightclubs, they reported that they had left a venue due to excessively loud music

"I know myself I left a few nightclubs because the music was too loud and you can't enjoy yourself because it's just pounding your head."

In Club I, the participants felt it was easier to accept wearing hearing protection because every employee had to wear it. In Club A, older co-workers who had tried the hearing protection encouraged younger employees to try it. In Club D, management did not hold staff meetings and the focus groups were the first time that security and bar employees had all sat down together and *"bonded".*

In Club D they felt that management did not consider their point of view, as long as the customers were happy then no action would was taken. One participant said

"It's about the wealth not about the health".

There was a different approach taken by management in Club A and Club I: they would ask the staff if they felt the music was too loud - as a result the staff felt they had a certain level of control over the music volume. Requesting DJs to turn the volume down and supplying earplugs were all management actions that participants recognised as management showing concern for noise in the nightclub.

It was agreed that a greater presence by the HSA would be of benefit to the management of noise in nightclubs. More frequent monitoring would increase awareness of the legislative requirements. However, a negative aspect of enforcement identified was the imposition of "*fines"* or *"shutting down"* a venue for a period of time since this action would affect customers satisfaction with the experience nightclubs provide.

7.1.3.7 Situational influences

This construct included participant's perceptions that reducing noise in their venue was beyond their control, as shown in Table 7.7 below.

Table 7.7: Summary of employee attitudes and key training points addressed based on the HBM construct: *Situational influences.*

Summary of employee attitudes	Key points to address during training
Fatalistic acceptance that nightclub employees would have future hearing loss but that it was out of their control. *Suitable control measures for nightclubs.*	Control measures (based on HSA "Noise of Music" guidance document) were emphasised to the employees.

The participants felt they had chosen to work in the nightclub sector and were fatalistic in their acceptance that they would experience hearing loss as a result: this was summarised in the following sentiment;

"It's like smoke, there is a chance you're going to get cancer, drink, your going to damage your liver, it's your choice. You can obviously choose a different profession."

However, many participants felt that managers were becoming more aware of noise exposure and suitable noise control measures since being involved in the research.

Participants felt that making design changes to a nightclub would be difficult.

"It depends on the acoustics of the nightclub, sometimes you can't change it…usually the acoustics in a nightclub are done during the planning and that could be years ago."

The following suggestions were made by participants when prompted to brainstorm about suitable design changes the nightclubs;

- Restricting the bands use of loudspeakers.
- Zoning the areas of the nightclub, making it quieter in the bar areas.
- Removing the need for hearing protection.
- Limit the bass of the songs, equalise the sound.
- Increase the distance of the bands/dance floor to the bar and circulation areas.
- Reduce the reverberation of the nightclub.
- Job rotation.
- Hearing protection for staff.
- Quiet areas for the patrons.
- Phasing the sound to create a noise cancelling area for the bartenders.
- Hearing testing.

7.1.3.8 Focus group participants recommendations

The focus groups were highly praised as a worthwhile exercise that was enjoyable for the participants. Table 7.8 and Table 7.9 summarises the participants specific recommendations related to the delivery of the noise awareness training and ideal hearing protection for the nightclub industry.

Table 7.8 Preferred content and delivery of noise awareness training

Opinion	Example of a key participant comment
Participant led training.	*"The more interaction the better, the more you pick up."*
Limit PowerPoint.	*"I just drift off when I am looking at the screen."*
External expert trainer to deliver course.	*"Someone that actually knows about it that you can question about it and that knows the actual answers."*

Table 7.9: Design of suitable hearing protection

Opinion	Example of a key participant comment
Clear or flesh coloured	*"That would be a major problem...having (orange earplugs) sticking out of your ear." "(Clear earplugs) are more discrete and hidden away from the customers."*
Easy to insert	*"It takes a while for the foam earplugs to expand".*
Recyclable.	*"Disposable earplugs would probably cost them (employer) more."*
Not accessible by patrons.	*"The customers could pull them out."*

7.2 Increased knowledge and change in adapted HBM attitudes

The participants in the training intervention included 15 employees from Club I and 19 employees from DB 5. Participants attended noise awareness training courses given in their venue. Club A was chosen as the control group and 15 employees completed the pre and post training questionnaires.

7.2.1 Demographics in Club A, Club I and DB 5.

Demographic responses at the pre-training visit were compared in all 3 venues using chi-squared and ANOVA analysis to see whether there were significant differences in between the 3 venues that might influence the effectiveness of noise awareness training. Participant profiles in terms of their gender, age, education, participants' roles in the venue, years working in the nightclub industry and years working in their current venue did not differ greatly between the 3 venues, as shown in Table 7.10. There was a significant difference between venues in the number of hours worked by employees ($p < 0.01$). Employees in DB 5 worked longer hours (M=34.4, SD= 9.8) than the employees in Club A (M= 20.7, SD = 13.9) and Club I (M = 18.7, SD = 10.2) respectively.

Table 7.10: Characteristics of the noise awareness training sample population (N=49)

Variables	Club A n = 15	Club I n = 15	Discobar 5 n = 19	*p* value
Gender				**0.469***
Male	11 (73%)	9 (60%)	15 (79%)	
Female	4 (27%)	6 (40%)	4 (21%)	
Age	M = 24.8 SD = 3.8	M = 25.5 SD = 4.8	M = 26.8 SD = 4.4	**0.399****
Education				**0.456***
Missing data	3 (20%)	2 (13%)	1 (5%)	
Primary school	0 (0%)	0 (0%)	1 (5%)	
Junior certificate	1 (7%)	1 (7%)	2 (11%)	
Leaving certificate	6 (40%)	2 (13%)	7 (37%)	
College/3rd level	5 (33%)	10 (67%)	8 (42%)	
Role				**0.216***
Bartenders	5 (36%)	6 (40%)	11 (58%)	
Security personnel	0 (0%)	2 (13%)	0 (0%)	
Glass collector	8 (57%)	4 (27%)	5 (26%)	
Cloakroom	0 (0%)	1 (7%)	0 (0%)	
Manager	1 (7%)	2 (13%)	3 (16%)	
Total years working in the nightclub industry	M = 4.8 SD = 3.6	M = 4.0 SD = 3.4	M = 6.0 SD = 4.0	**0.303****
Years working in their current nightclub	M = 3.4 SD = 1.6	M = 2.8 SD = 2.3	M = 2.1 SD = 2.1	**0.193****

* chi-squared statistical test ** ANOVA

Figure 7.3 below indicates the nationality of training participants. Half of the participants were Irish. ANOVA identified that there was no significant difference between the nationalities of the participants in the three venues (*p* > 0.05).

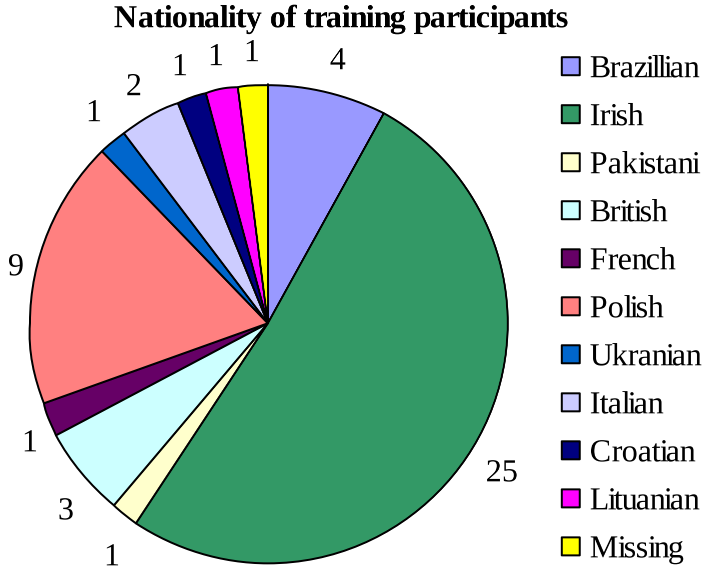


Figure 7.3: Nationality of training participants (n =49)

7.2.2 Intervention group versus control group

In the control group (Club A), each of the 15 participants were given a questionnaire to complete but did not participate in the training. Significant differences between the intervention and control group demographics were examined by chi-square analysis and independent T-tests. No statistical differences were observed between the control group and the intervention groups who participated in the training with respect to gender, age, education, participants work roles in the venue, years working in the nightclub industry or years working in their current venue.

Two training participants did not answer the demographic questions. The mean age for the total group (n = 47) was M = 25.8, SD = 4.4. The mean number of years of working in the nightclub sector for the total group was M = 5.1, SD = 3.7. The mean number of weekly hours spent working in the nightclub sector for the total group was M = 25.5, SD = 12.6. In each case summarised in Table 7.11, the differences were not significant between the intervention and control group demographics ($p > 0.05$). Also, the intervention groups and control group did not differ significantly in their responses to any of the questionnaires adapted HBM sub-scales prior to training ($p > 0.05$).

Table 7.11: Characteristics of the intervention and control groups (n = 49)

Variable	Intervention group	n	Control group	n
Age	M = 26.2, SD = 4.6	34	M = 24.8, SD = 3.8	13
Total years working in the nightclub industry	M = 5.2; SD = 3.8	32	M = 4.8; SD= 3.6	14
Weekly hours spent working in the nightclub sector	M = 27.5; SD = 12.6	34	M = 20.7; SD= 13.9	14

An independent T-test was performed to determine whether any of the demographic variables were related to either baseline or post-test scores. Participants who had English as their first language scored significantly higher in knowledge baseline scores than participants who were non-nationals ($p = 0.004$). The mean score on the baseline test for Irish employees was 54.2% and 38.5% for non-national employees. After training, the difference in knowledge between Irish and non-national employees was not significant (M= 67.1%, M = 58.8% respectively: $p= 0.326$). These findings indicate that non-national participants had slightly less knowledge than Irish employees initially, but by the end of the training these differences had disappeared.

7.2.3 Pre to post test differences for intervention/control groups

The means and standard deviations for the pre and post-test scores were calculated for the each group for the total test (see Table 7.12). Paired samples T-tests were used to identify whether there were any significant differences between the pre and post-test mean knowledge scores. For the intervention group, differences between the pre and post-test means scores were significant (t= -5.832, df = 33, $p < 0.01$). After an 8-week time lapse, intervention group participants had still retained the bulk of knowledge from the training as shown by a paired sample T-test between the post-test mean knowledge scores and the 8-week revisit mean knowledge scores (t= -0.882, df = 33, $p = 0.384$). Differences between the means knowledge score for the control group, at any time interval were not significant ($p > 0.05$). While there was no significant difference between the intervention and control groups at the baseline ($p > 0.05$) following the training intervention there was a significant difference between the two groups post test and at the revisit 8 weeks later ($p < 0.05$).

Table 7.12: Mean differences in knowledge between groups and times

Knowledge	Baseline mean (SD)	Post test mean (SD)	Revisit 8 weeks later mean (SD)
Intervention group (n = 34)	48.2% (19.1)	69.7% (19.2)	73.1% (14.8)
Control group (n = 15)	43.6% (19.6)	39.3% (22.2)	46.2% (24.0)

7.2.4 Adapted HBM attitude changes

Each of the 6 constructs from the adapted HBM (see Chapter 4, section 4.2.3.1) was assessed using Cronbach's alpha (please refer to Chapter 4, section 4.5.2.2). Three of the final components, barriers to hearing protection use, interpersonal influences and self efficacy had a Cronbach's alpha > 0.7 and hence the results were represented as a group. All other components had a Cronbach's alpha ranging from 0.1-0.6, and these items were analysed individually. Similar results were reported by Edelson *et al.,* 2009 and also by Neitzel *et al*, 2008. The final items for the intervention group are presented in Table 7.13.

Table 7.13: Intervention group results for HBM constructs

Adapted HBM construct	Baseline		Post training		Change
	N	Mean (SD)	N	Mean (SD)	*p* value
Susceptibility to NIHL					
Loud music can damage hearing.	33	4.33 (0.9)	33	4.36 (0.9)	0.823
Earplugs can protect hearing.	33	4.19 (0.8)	33	4.28 (0.6)	0.447
Severity of NIHL					
General impairment*	33	4.33 (1.0)	33	4.52 (0.8)	0.280
Communication impairment	32	4.22 (1.2)	32	4.13 (1.0)	0.742
Benefits of preventative action					
Use of hearing protection	32	3.94 (1.2)	32	3.88 (1.0)	0.813
Important to prevent	32	4.22 (1.0)	32	4.41 (0.6)	0.245
Barriers to hearing protection use (6 items)	32	2.56 (0.7)	32	2.46 (0.6)	0.353
Interpersonal influences (2 items)	33	2.91 (1.3)	33	3.06 (1.1)	0.320
Self efficacy (3 items)	33	3.54 (1.1)	33	4.30 (0.5)	0.005

* Answer scores reversed for analysis

The intervention and control groups were not significantly different in their responses at baseline ($p > 0.05$). Self efficacy was the only adapted HBM construct that was significantly different for the intervention group following the training intervention ($p < 0.01$). This finding was similar to that of Neitzel *et al.*, (2008) who also did not find any significant difference in HBM constructs following training. The control group did not have any change in their self-efficacy post-test ($p = 0.418$).

After the training intervention, an independent T-test showed that there were significant differences between the intervention and control groups for the following 2 constructs:

1. Susceptibility to NIHL: Earplugs can protect hearing ($p = 0.038$)
2. Interpersonal influences: 2 Items ($p = 0.04$).

The intervention group post-training were more positive than the control group about hearing protection, indicating that it would assist in saving their hearing from becoming damaged and that co-workers would encourage hearing protection use. Eight weeks after the training the intervention group were still of the opinion that earplugs could protect their hearing ($p = 0.023$) and were confident in their self-efficacy ($p < 0.01$). The interpersonal influences were not significantly different after the 8 weeks ($p > 0.05$).

7.2.5 Participant training evaluation

All training participants (n = 49) were invited to complete an anonymous training evaluation immediately following the session. Thirty eight participants (response rate = 88%) completed the evaluation. The participants were very positive towards the training with the majority rating the practical examples of hearing loss, opportunity to discuss noise issues and to try out different types of hearing protection useful or very useful. The participants rated all the information provided during the noise awareness training to be useful or very useful. Each aspect of the training was identified at least once as the most useful part of the training delivered. The most valued part of the training was raising awareness that noise levels might cause hearing loss (see Appendix 13 for a copy of the evaluation form).

7.3 Measure of intermediate outcomes after the noise awareness training

The effectiveness of management policy relating to hearing protection use, in Club A, Club I and DB 5 was recorded at baseline, post-training and 8 weeks later. The results were analysed to assess how often hearing protection was used by the employees. Safety solutions may fail if attitudes to safety are poor (Williamson, 1997). Consequently, safety culture was also examined to identify whether the employees perception of managements role in safety was effectively communicated in the venues.

7.3.1 Use of hearing protection

The employees in Club A, Club I and DB 5 were asked (see Appendix 12) about how often they currently wore or planned to wear hearing protection in their workplace. A paired sample T-test revealed that participants in DB 5 would wear their hearing protection more often having attended the noise awareness training ($p < 0.01$). At the 8-week revisit, the DB 5 employees had not returned to their baseline attitudes to wearing hearing protection ($p < 0.01$); however, their use of hearing protection was not as significantly improved ($p > 0.05$). The control group, Club A did not have any significant differences in their use of hearing protection at any stage of the intervention ($p > 0.05$).

Employees were asked to rate their likelihood of using the hearing protection (behavioural intention) using the Likert scale. Two items were used to measure participants' behavioural intentions at each test occasion (Cronbach's alpha > 0.7). While the behavioural intentions rose after the training intervention, none of the venues had a significant difference in their behavioural intentions ($p > 0.05$) (Figure 7.4).

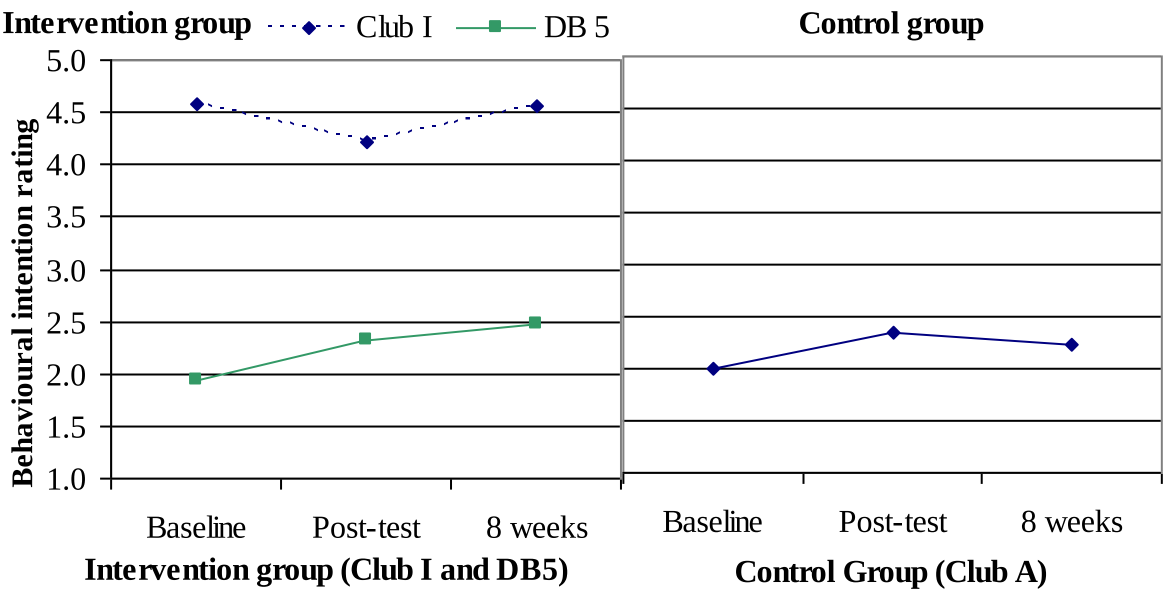


Figure 7.4: Behavioural intentions for the intervention (n =34) and control (n = 15) groups on the three test occasions.

Ratings were high in Club I where management already enforced the use of hearing protection in the nightclub. The training in DB 5 did improve the participants behavioural intentions but, presumably due to the lack of encouragement by the management the behavioural intentions, they were not as high as Club I. Although the control group in Club A showed improved ratings after completing the post test, the improvement was not sustained.

7.3.2 Safety Culture

Immediately after the training intervention and 8 weeks later, participants in the 3 venues completed a 26-item questionnaire on the safety culture in their venue. The reliability analysis on the post-training safety culture gave a Cronbach's alpha of 0.523. On the 8 week safety culture scale the Cronbach's alpha was 0.324.

ANOVA analysis was conducted to explore whether there was a significant difference between venues in the 6 constructs that made up the safety culture scale. Club I participants responses were significantly higher than their counterparts in Club A and

DB 5 for risk justification and safety climate post training ($p < 0.01$ in both cases). In Club I, the employees felt they had worked unsafely in the past because they did not know what they were "*doing wrong*" at the time or the right equipment was not available to them. In addition, the Club I scored higher on their beliefs relating to the following 6 safety climate items:

1. My managers set a good example for me when it comes to wearing hearing protection.
2. I do not think preventing hearing loss from noise is very important to my managers (reversed for Likert scale analysis).
3. My manager frequently checks to see if I am obeying the safety rules.
4. My manager does remind me to work safely if I am not doing so.
5. My manager says a "good word" to me if I pay extra attention to safety.
6. My manager would never say I have to wear my hearing protectors, even I they are not comfortable (reversed for Likert scale analysis).

7.4 Chapter summary

This chapter summarised the findings generated from the noise risk communication methods used to develop and deliver a sector specific noise awareness training programme. It also describes a pilot study conducted to assess the effectiveness of such training.

There was a profound lack of knowledge of the Noise Regulations, 2007 requirements among managers. Focus groups were used to explore the reasons why two-thirds of venue employees would not wear hearing protection in their workplace. The focus groups showed that employees had a fatalistic acceptance that hearing loss was inevitable and that they were powerless to prevent NIHL. Participants pointed out that one type of hearing protection did not suit all employees and that there was a need for training that showed the long term effects of noise exposure on hearing.

A sector specific noise awareness training intervention showed that for the intervention group, differences between the pre and post-test mean knowledge scores were significantly different ($p < 0.05$) and that training significantly improved their confidence in inserting hearing protection correctly. However, noise awareness training may not have been as effective due to lack of management commitment to encourage/enforce the use of hearing protection by staff.

Chapter 8 will discuss the main findings from the noise risk communication results.

Chapter 8

OVERALL DISCUSSION

AND

RECOMMENDATIONS

8.0 Introduction

This chapter will discuss the main findings from the thesis, which weaves all 3 aspects of risk analysis together. The chapter is split into the following 5 main sections:

1. Noise exposure and its effects.
2. Compliance with the Noise Regulations, 2007.
3. Recommended noise control measures for venues.
4. Focus groups.
5. Culture, opinions of stakeholders and challenges facing the industry.

Finally the chapter outlines recommendations based on the research findings and identifies future research.

8.1 Noise exposure and its effect

This study gives a more comprehensive picture of Irish music venue employees' noise exposure than the study by Mitchell (2001) whose study was confined to patron exposure on the nightclub dance-floor. This work allows us compare the noise levels in Irish entertainment venues with those of the rest of the world.

In this study, nightclub bartenders in the bar area closest to the dance-floor were found to have an $L_{EX,8h}$ between 84.0-98.4 dBA compared to discobar bartenders 71.4-98.4 dBA. These finding are in line with international studies carried out in the UK (Whitfield 1998; Sadhra *et al.*, 2002 and Barlow and Castilla-Sanchez, 2012) and in Australia (Guo and Gunn, 2005), all of whom found that bartenders in amplified music venues had a $L_{EX, 8h}$ ranging from 72.2 to 98 dBA.

Findings from 80 questionnaires combined with 95 dosimeter readings indicated that the average nightclub bartender worked a 5-hour shift with a $L_{EX, 8h}$ of 92.3 dBA (SD=3.8). This level of exposure was significantly higher than the average discobar bartender $L_{EX,8h}$ of 89.1 dBA (SD=5.4; $p < 0.05$). A preliminary study from this research (based on 19 dosimeter results, measured in 9 nightclub venues) found that the average nightclub bartenders $L_{EX, 8h}$ was almost 4 times above the accepted legal limit (Kelly *et al.*, 2012).

8.1.1 Specific factors that increased noise exposure

The focus group participants identified live bands playing in venues as significantly louder than music played by DJs. This was due to bands playing music through their own loudspeakers rather than using in-house loudspeakers which were more easily controlled. In Australia, Guo and Gunn (2005) identified that bartenders and glass collectors working in live music venues were exposed to a mean $L_{EX, 8h}$ that was 4 to 5 dBA higher than their colleagues who were exposed to amplified music from DJs.

Noise risk assessment in this study found increased noise exposure for bar employees who disposed of glasses during their work-shift. The employees in the focus groups reported that music needed to be loud to drown out the sound of glasses breaking during nightclub operation. Eliminating the use of glass in the nightclub industry has been suggested by other authors (mainly to tackle the issue of glass related assaults and accidental injuries) (Forsyth, 2008; Luke *et al.*, 2002). For example in Glasgow, since 2006, a bye-law was introduced to ban the use of glassware in all venues holding an entertainment licence, including nightclubs (Winder and Wesson, 2006).

8.1.2 Effects of noise exposure on employees

Several studies have highlighted the negative auditory effects that occupational exposure to loud music in entertainment venues can have on employees (Sadhra *et al.,* 2002; Bray *et al.,* 2004; Santos *et al.,* 2007). The 30 DJs in the hearing loss study by Santos *et al.,* did not see any need for change to the industry even though the researchers informed them that their temporary hearing loss was due to exposure to noise levels (L_{Aeq}) of 93.2-109.7 dBA.

Focus group participants in this study were fatalistic and although they acknowledged that exposure to noise in nightclubs could lead to hearing loss in the distant future they felt there was very little that they could do to prevent this from happening.

Axelsson (1999) showed that damage caused by amplified music may manifest itself in the form of tinnitus rather than as a reduction in hearing thresholds. The focus group participants, who did not wear hearing protection, frequently had ringing in their ears after work. Gunderson, Moline and Catalano (1997) indicated that the prevalence of tinnitus worsens with increased length of employment in nightclubs. Given the young demographic working in entertainment venues, it has been suggested that there are a particularly high number who are at risk of NIHL (Barlow and Castilla-Sanchez, 2012).

8.1.3 Extension of operating hours in nightclubs

Ireland has earlier closing times than other European countries, consequently it may be reasonable to suggest that Irish nightclub employees have a reduced risk of hearing loss. The Irish Nightclub Industry Association (INIA) has proposed that city centre nightclubs should be licensed to extend their operating hours to 04:30 (Gurdgiev, 2009). If the INIA proposal was adopted by Government the employees exposure time to amplified music would increase. An INIA report highlighted the drink related health issues associated with the extension of nightclub opening hours but did not consider the effect on noise exposure.

8.2 Compliance with the Noise Regulations, 2007

The Noise Regulations, 2007 set exposure criteria that represent a level of "acceptable" hearing loss risk for the general working community (Williams and Burgess, 2007). This research reveals a profound lack of knowledge and non implementation of the Noise Regulations, 2007. Ignorance of the legislation is never a viable defence in health and safety liable cases. In a study published during the course of this work Barlow and Castilla-Sanchez (2012) pointed out that the music industry were ignoring its legal responsibility to protect staff from high noise levels.

8.2.1 Exposure limit values

The Noise Regulations, 2007 L_{Cpeak} exposure limit value (140 dBC) was exceeded by 24 bartenders. Noise causes acute mechanical damage to hair cells of the cochlea in the inner ear when the short-term sound intensity or peak impulse noise levels are very high $P_{peak} > 137$ dBC (Maassen, 2001).

Suggestions have been made in the past that the minimum noise level to provide satisfactory music entertainment is typically 94-96 dBA (Mawhinney and McCullagh, 1992; Dibble, 1988). Bearing this in mind it is no surprise that the majority of the venue employees had a $L_{EX,\ 8h}$ that exceeded the exposure limit value (87 dBA). Nightclub bartenders had a significantly higher mean $L_{EX,\ 8h}$ (by 3 dBA) than discobar bartenders ($p < 0.05$).

8.2.2 Legal requirements

In addition to exceeding the exposure limit values, the venues also neglected to put in place the legal actions required when the lower and upper exposure action values were exceeded. This issue is not unique to Irish amplified music venues. Recently in Australia it has been recommended that nightclub operators reduce noise levels, display warning signs and provide earplugs for employees and patrons (Beach, Williams and Gilliver, 2012).

8.2.2.1 Poor quality of risk assessments

Although 75% of venues had a safety statement and 2 had a noise risk assessment, only one venue had documents available to view. The quality of noise risk assessments was poor in venues *e.g.* only 1 noise measurements taken for each employee location to calculate employees $L_{EX,8h}$ and there was no recommendation for suitable hearing protection. Environmental Health Officers (EHO) in NI identified that risk assessments were difficult to request from nightclubs since there was a lack of suitable consultants to carry out the risk assessment. An extensive survey by Birmingham City Council found that only 1 of 31 nightclubs inspected had a satisfactory noise risk assessment (Morris, 2006).

It is important to measure noise levels that are representative of the noise levels that employees experience, for this reason it is essential that a guide for noise risk assessments be developed specifically for the nightclub sector. Any noise measurement strategy would need to take the variation in noise levels into account. The cocktail effect, originally identified by Bikerdike and Gregory (1980) whereby the noise levels in amplified music venues tend to rise by 5 dBA as time passes, was observed in the Leinster venues. The noise level rose from 23:30 to 01:00 by an average of 5 dBA (90 – 95 dBA) in nightclub venues and by 2 dBA in discobar venues. Similar findings have been reported in other studies (Sadhra *et al.*, 2002; Whitfield, 1998). The highest noise levels were observed between 00:30 to 01:00.

8.2.2.2 The use of audiometric testing to protect hearing

None of the nightclubs or discobars had ever sent an employee for a diagnostic hearing test or had conducted hearing checks on their employees prior to employment in their venues. Pre-employment medical assessments can establish a baseline to determine whether an employee had suffered any health deterioration. Clearly, there are cost implications for conducting routine audiometric tests on employees.

Current audiometric testing has been reported as not being particularly sensitive to identifying noise induced hearing loss due to intrinsic test-retest variability (Lutman, Davis and Ferguson, 2008).

The EHOs in Northern Ireland (NI) did not routinely request training or audiometric files from venues. In addition, the managers reported being fearful that providing hearing tests would lead disgruntled employees to sue the venue for hearing loss. During the focus group sessions, all participants agreed that hearing tests were good for the industry as they would identify whether their hearing was being damaged and whether their hearing protection was suitable.

8.2.2.3 Selection and use of suitable hearing protection

If a person cannot hear a conversation at arms length the noise level is approximately 90 dBA (Health and Safety Authority (HSA), 2004). From the focus groups it emerged that bartenders lip-read orders from the customers and did not actually *hear* the orders placed. This lip-reading skill was not one that they had realised was helping them to communicate with customers.

The HSA's annual report of 2009 found that >80% of premises inspected used hearing protection (HSA, 2010). Although hearing protection was available in 4 nightclubs examined in this study, only 1 nightclub ensured that employees consistently wore them at work. None of the discobars provided hearing protection to their employees. Hearing protection was identified by the managers as a control measure they would put in place. However, employees highlighted fears that hearing protection would restrict their ability to hear customers' orders. The Western Australia equivalent of the Irish HSA conducted a review of amplified music venues compliance with noise legislation in 2000 and conducted a follow up review in 2004/2005. During these inspections they discovered that the employees' main reason given for not wearing hearing protection were that hearing protectors affected their ability to hear what people where saying (Guo and Gunn, 2005). The results from this research indicate that the Irish employees were of the same opinion.

The effectiveness of hearing protection depends on factors such as correct selection, use, care and maintenance (British Standards, 2004). Selecting suitable hearing protection is one of the essential elements of the noise risk assessment process. Overprotecting employees will mean they will be reluctant to wear hearing protection. The music played in the Leinster nightclubs and discobars featured sounds that were more prominent in the lower frequencies (63 and 125 Hz). These frequency bands are often dominant in amplified music (Davies *et al.*, 2005). Sadhra *et al.* (2002) found that, especially after midnight, the lower frequencies (250 and 500 Hz) became more prominent. Hearing protection predominantly blocks out the higher frequency bands (1000-4000Hz) since this is the region where the ear is most sensitive.

During the focus group sessions, employees who had tried the hearing protection, selected using octave band analysis, accepted that the earplugs helped them to hear customers' orders and caused the music to fade into the background. Some of the employees found it difficult to insert the hearing protection. After the noise awareness training intervention, participants became more confident in their insertion techniques. According to previous reports, employees instructed on the correct insertion of hearing protection have displayed improved ability to insert hearing protection correctly (Murphy *et al.*, 2011; Tsukada and Sakakibara, 2008).

The focus groups in this study also revealed that wearing hearing protection in the nightclub eradicated ringing in the ears after work. Schmuziger (2006) reported that the consistent use of hearing protection reduced the amount of permanent hearing loss. Suitably selected hearing protection and employee noise awareness training are essential to control the risk of hearing loss to employees. However, hearing protection is not a one-fits-all solution. Focus group participants differed in what hearing protection they would be happy to wear in their workplace.

Currently, there are a limited number of hearing protectors on the market that satisfy all of the focus group participants criteria: clear/flesh coloured, easy to insert, reusable hearing protection that was discrete and did not distort speech frequencies. Barlow and Castilla-Sanchez (2012) and Patel (2008) have referred to the beneficial use of "musician's ear plugs" to keep their tonal balance intact. However, these specialised earplugs often need to be custom moulded to the wearer, cost more than €100 per pair and ultimately will not suit the high staff turnover in the entertainment industry. Alternative flat-frequency response hearing protection, costing €15 per pair, is available and is equally as effective.

There is scope to develop hearing protection tailored for the entertainment industry, at a cost point that would be within their budget e.g. similar to the Howard Leight Smart reusable earplugs (costing €0.50 per pair) but more discrete than their orange colour.

8.2.2.4 Noise awareness training

In previous studies it was found that amplified music venue employees had poor awareness of the need to protect their hearing (Guo and Gunn, 2005; Sadhra *et al*, 2002; Whitfield, 1998). The data collected from this research concurs with their findings. All enforcement officers felt that noise awareness training for venue employees was an essential requirement of the Noise Regulations. Lutman, Davis and Ferguson (2008) also identified that there needed to be continuous efforts at raising awareness in all noisy industries.

The quality of noise awareness training needs to be addressed in order to improve knowledge of the Noise Regulations, 2007 and to support managers in developing a greater understanding of the legislation. The sector specific noise awareness training piloted in this study significantly improved employees knowledge of the Noise Regulations, 2007 requirements and significantly improved their confidence in inserting hearing protection correctly. However, the noise awareness training may not have been as effective as desired because there was little attempt in Club A and DB 5 managers to encourage or enforce the use of hearing protection by staff. It was not expected that Club A and DB 5 were outliers as Barlow and Castilla-Sanchez (2012) also identified that management were not sufficiently committed to encouraging the use of hearing protection.

8.2.2.5 Weekly employee noise exposure

Cabot (1979) and Bickerdike and Gregory (1980) reported that re-measuring the same nightclub on different nights gave results which were repeatable within 1-2 dBA. Their findings were supported by later studies (Whitfield, 1998; Sadhra *et al.*, 2002; Bray *et al.*, 2004). In this study, the employees $L_{EX, 8h}$ calculated from revisits 80% of venues (12/15) were repeatable within 1-2 dBA of each other.

The research in this thesis began 8 months after the revised Noise Regulations, 2007 were introduced to the entertainment industry. During this time the economic crisis hit the nightclub industry, with an estimated 30% decline in the number of nightclubs from 2006 to 2011 (Foley, 2011). The number of operating nights also reduced to an average of 2.7 nights per week in 2010 (Foley, 2011).

The “Noise of Music” guidance document (2009) allows entertainment workplaces, where an employee’s working week is 3 (or fewer) days, to use a weekly noise exposure level calculation, rather than a daily noise exposure level calculation. However, the Noise Regulations, 2007 specify that the weekly noise exposure level can only be used when the exposure limit value does not exceed 87 dBA and appropriate control measures are taken to reduce noise risk. Weekly calculations are generally not appropriate for venues because most employees’ daily noise exposure exceeded 87 dBA.

8.3 Recommended control measures for venues

Generally inspectors measuring compliance with legislation will use a guidance document which illustrates best practice (Health and Safety Executive (HSE), 2005). Each of the venues noise control measures were inspected based on the Noise Regulations, 2007 and the HSA “Noise of Music” guidance document. Significantly, more nightclubs had a combination of control measures in place compared to discobars. A survey of EHOs in NI showed improvement notices had been served by 5 EHOs specifically requesting guidance document measures to be put in place *e.g.* staff rotation, facing speakers away from bar areas or installing a sound limiter device.

8.3.1 Publicise the "Noise of Music" guidance document

Australia, Switzerland, Italy and Finland have set exposure limits for employees working in the entertainment industry, which are the same legal limits as for other industries. In doing so, the message is sent that exposure to high volume *music* can put employees at risk and preventative measures should be taken to avoid the onset of NIHL (Santos *et al.*, 2007). The "Noise of Music" guidance from the HSA is directed at the amplified music sector and is available to download for free from the HSA website (HSA, 2009). Two of the venue managers were aware of the existence of this guidance document and the control measures it outlined.

8.3.2 Design of venues

The venue managers were least likely to redecorate the nightclub with absorbent materials as a risk management strategy presumably due to the cost of carrying out this noise control measure. Risk management is based on an evaluation of costs versus the risk to health. The 2009 ruling in Baker Vs Quantum Clothing Ltd. in the United Kingdom (UK) concluded that the provision of hearing protection was neither expensive nor difficult.

One EHO expanded on their opinion of enforcement actions to improve noise legislation compliance: the EHO felt there was a need for *"more prescriptive regulations"* specifically providing guidance on the engineering methods to adopt to design out *"excessive noise levels"*. This research has identified that venues that were attached to a hotel were significantly quieter than venues that were either stand alone or attached to a bar venue ($p < 0.05$). Distance of the bar from the dance-floor was not significant in determining employees daily $L_{EX, 8h}$.

8.3.3 Control of noise levels

Very few patrons (< 20) were observed in the nightclubs at the opening time of 23:30. In some venues, the DJ played music above 90 dBA regardless of whether there were patrons in the venue or not. Exposure to loud noise can lead patrons to experience reduced hearing sensitivity. This can make the music appear quieter than at the beginning of the night, leading to the noise level being turned up (Sadhra *et al.*, 2002). The venue managers assessed whether the volume was too high by carrying out a listening check. Many EHOs felt that management measuring noise levels would help to improve compliance with legislation.

8.3.4 Staff rotation

If a venue has a number of bar areas it may be reasonable to consider the rotating bartenders during their work-shift *e.g.* from the bar closest to the dance-floor to a bar which is further from the dance-floor (HSA, 2009). An issue with this strategy is employee accountability on tills. Many bartenders were assigned to a section of the bar with a till behind them in order to reduce the need to cross over their co-workers paths. If a rotation system was used staff would be crossing over from one bar to another and there would be a length of time where a bar was a bartender short, thus reducing productivity. Furthermore the other bars in the venues were not significantly quieter than those located closest to the dance-floor and hence the bartenders' noise exposure may not be significantly affected by the rotation between bars.

8.3.5 Wearing hearing protection during specific tasks

The HSE in the UK recommend that it is better to *target* the use of hearing protection and encourage people to wear it during specific tasks (HSE, 2008). Hearing protection is not necessary for all employees in the venues. Generally employees located outside the main areas, for example cloakroom attendants or security outside did not need to wear hearing protection. On the other hand, DJs and security personnel located close to the dance-floor were exposed to the highest noise levels. These finding are in line with other studies (Bray *et al.,* 2004; Guo and Gunn, 2005).

Security personnel needed to wear earpieces in order to communicate with each other. Due to the noise levels on the dance-floors, the security needed to have the volume of the earpieces up very high. Thus, not alone are they exposed to loud music but the earpieces could potentially be adding to their noise exposure.

8.4 Focus groups

Many studies related to hearing protection use have involved focus groups (Stephenson and Stephenson, 2011; Tantranont *et al.,* 2009; Patel *et al.,* 2001). Since there had never been a focus group study for nightclub employees it was of interest to explore this method. The focus groups were well received as a worthwhile exercise that was enjoyable to participants since it allowed them to describe their perspective of the industry. The focus groups gave a much deeper level of understanding of the barriers faced by the employees, especially relating to hearing protection use and management engagement. Data gathered from the focus groups made it possible to design a sector specific noise awareness training programme that addressed the adapted Health Belief Model (HBM) constructs.

Focus group findings, *e.g.* difficulties fitting hearing protection, inability to hear speech or lack of supervisor support corresponded with findings reported for focus groups studies carried out in other sectors *for example:* manufacturing (Tantranont *et al.*, 2009), construction (Robertson *et al.*, 2007) and the military (Abel, 2008).

8.5 Culture, opinions of stakeholders and challenges facing the industry

The HSA's guidance document on noise management in the entertainment industry, "Noise of Music", suggested that the entertainment sector needed to be made aware that excessive noise exposure has the potential to cause permanent hearing loss. The guidance document pointed out that changes would require a considerable shift in attitudes and culture.

8.5.1 Change of culture in amplified music venues

It was evident that the venue managers were not keeping up to date with developments in health and safety legislation. They recognised that venues had loud music and were generally noisier for the employees than other industries. However, this was the accepted norm or *"par for the course".* The entertainment industry is capable of change, but needs to be better informed about suitable noise control measures for their venues. During the focus groups, many participants felt that managers were becoming more aware of the effects of noise since this research commenced in their venue.

8.5.2 Managers support for the use of HPD

Many employees had preconceived notions concerning the cumbersome nature of hearing protection. Thus, many reported finding hearing protection more beneficial than they expected. While the noise awareness training significantly improved the employees self-efficacy, this was not sufficient to ensure that employees wore the hearing protection in their workplace *after* the training. There was quite a variation in the acceptance of hearing protection, which was clearly influenced by managements engagement and encouragement. The practice, by management in some venues, of asking employees to sign a waiver to allow them to dispense with hearing protection did not send out a positive safety climate message. Recently, a study of 20 music venue patrons identified that awareness of the benefits of earplugs and appreciation of the long-term implications of hearing damage and high self-efficacy were key variables in ensuring compliance with the wearing of hearing protection (Beach, Williams and Gilliver, 2012).

8.5.3 Interaction between nightclubs and enforcers

None of the venues were inspected or had interactions with the HSA related to noise. The focus group employees believed that a greater presence by the HSA would be of benefit to ensure the management of noise in nightclubs. EHOs, in NI, felt that supporting the managers to become compliant with the legislation was preferred over legal enforcement and fines. Half of the EHOs agreed that objecting to late night operating licences based on non-compliance with the Noise Regulations was a more effective method to improve enforcement of the legislation than serving improvement notices.

The enforcing agency has an important role to play in ensuring compliance with legislation. As observed by Groothoff (1999) an increase in inspections and one-to-one guidance from the enforcement agency helps amplified music venues become compliant. If the current number of inspectors is inadequate more officers dedicated to this industry would be desirable. In other countries the enforcement of the occupational noise legislation in entertainment venues is within the remit of the EHOs. However, in the Republic of Ireland the EHOs do not have authority to enforce the Noise Regulations, 2007.

8.5.4 Northern Ireland EHOs

The EHOs surveyed in NI recommended a noise awareness training course specifically aimed at venue managers. Managers would then best placed to deliver noise awareness training to the employees.

The provision of audiometric testing was regarded as a highly beneficial legal requirement by the EHOs. They felt that personal protective equipment should be the last option to choose. The EHOs pointed out that they lacked experience in using noise monitoring equipment and in evaluating suitable hearing protection. Budget constraints in their departments made up-skilling difficult.

8.5.5 Challenges facing the nightclub industry

If the INIA were to be successful in lobbying the government for changes to the operating hours then the late night amplified music industry needs to strictly adhere to the legislative requirements relating to occupational noise in order to protect their staff. Currently, there is no definition of a nightclub in Irish legislation (Gurdgiev, 2009). Nightclub managers felt it was only fair that the Noise Regulations, 2007 were enforced in all entertainment venues, including discobars where loud music was played.

The main challenge faced by the industry was striking a balance between compliance and maintaining the atmosphere the customers expected from the venue.

8.6 Recommendations

This section outlines some recommendations that can be made based on this research. Discobars should be considered comparable to nightclubs in relation to these recommendations.

It is recommended that any amplified music venue seeking a Special Exemption Order (SEO) would also be required to provide evidence that they are in compliance with the requirements of the Noise Regulations, 2007.

HSA inspectors should be required to submit licence suitability reports annually for amplified music venues seeking new licences. Their report on suitability should be based on the venues compliance with the Noise Regulations, 2007 and adherence to the control measures outlined in the HSA "Noise of Music" guidance document.

Prior to any extension of the operating hours of amplified music venues, a system of ensuring venues compliance with the Noise Regulations, 2007 requirements is essential. The HSA "Noise of Music" document is currently a guidance document outlining measures that may be taken to manage noise in the entertainment industry. It is recommended that the "Noise of Music" document would be divided into sector specific sections, similar to the "Sound Advice" document in the UK. Additionally it would be beneficial to upgrade the "Noise of Music" document from a guidance document to a Code of Practice (COP) as this would provide practical guidance for the observance of Noise Regulations, 2007. This strategy would grant the enforcement officials more power to enforce the specific technical and organisational control measures suitable to the nightclub industry and also protect employers who adhere to the COP in any court proceedings.

It is recommended that enforcement officers should have a greater presence and better support the amplified music venues. EHOs, who already conduct food safety inspections in amplified music venues, could be issued with a service contract to inspect for compliance with the Noise Regulations, 2007. Even though EHOs in many other countries are responsible for enforcing health and safety in food/beverage industries, in Ireland, the EHOs do not have these responsibilities.

Continuous Professional Development (CPD) is essential for any EHO enforcing the Noise Regulations, 2007 in amplified music venues. While the Environmental Health degree in Dublin Institute of Technology includes noise, there is a need for it to be expanded to include practical demonstrations of the use of sound level meters and dosimeters. Focus group studies should be conducted with EHOs in Ireland to identify the knowledge gaps they have in relation to: measuring noise levels, the noise legislation, technical and organisational control measures and selection of suitable hearing protection.

It is recommended that an occupational noise risk assessment standard is drafted to demonstrate what is considered to be a suitable occupational noise risk assessments for amplified music venues. The standard could include requirements for octave band analysis to be conducted to assist in the selection of suitable hearing protection. Noise measurements should take account of the "cocktail effect". It might also include a stipulation that the impact of different operating nights on employees noise exposure be taken into account during the risk assessment.

The Noise Regulations, 2007 stipulate that employers shall provide employees with suitable and sufficient information and training relating to the risks resulting from exposure to noise. The entertainment industry has many hazards for which employees need training such as noise, manual handling, food safety, glass disposal and responsible serving of alcohol. In Europe, it has been mandatory that construction industry employees undergo a prescribed health and safety awareness and practical training. To ensure that employees or contractors have completed this training, entry to construction sites has been restricted to those who can prove that they have undergone the necessary training. This study recommends that a similar prescribed health and safety training course be developed for the amplified music industry, in partnership with enforcers and the industry.

As emphasised by this research, the delivery of noise awareness training to employees is irrelevant if management are not committed to a positive safety climate in their venue. A noise related training programme for management should be designed and delivered in partnership with the INIA. The programme content should include the following list of topics:

1. Legislative Noise Regulations, 2007 requirements.
2. How to develop a positive safety climate in your venue *e.g.* management to facilitate meetings with staff related their health, safety and wellbeing.
3. Methods to select suitable hearing protection.
4. Suitable noise control measures to be put in place in venues.
5. Peer-led learning whereby case-studies from managers who have implemented noise control measures successfully were examined.
6. How to spot-check the noise level in a venue.

Management should also be encouraged to experiment with reducing the noise levels and to ask for feedback from staff and customers to see whether a reduction in music levels was noticed by patrons. Requesting patrons to complete customer satisfaction surveys from the venues website may be one method to achieve this feedback.

In addition to the key recommendations above, the following points are also important:

1. Managers to apply control measures with live bands requiring that noise levels be kept to a certain limit and only permitting them to use loudspeakers that are safely raised off the ground away from employee and patron ear height.
2. Management should ensure DJs understand that they need to keep the music volume low until a significant number of patrons enter the venue.
3. Management to include hearing protection on employees contracts of employment. Hearing protection to be referred to as part of the employees' uniform.
4. Security personnel working in the venue to be issued with noise cancelling earpieces that sufficiently block excessive noise levels while also permitting speech.
5. Mass media to be used to publicise the use of hearing protection in venues. This should explain the risks involved in excessive exposure to loud music over long periods.
6. Manufacturers of ear plugs to design cost-effective comfortable, clear, discrete, reusable hearing protector suitable for wearing in the amplified music sector that allow speech frequencies to remain clear.

8.7 Limitations of research

While this thesis has represented a substantial body of work there are certain limitations that need to be taken into account:

- A convenience sample of venues was used. This was the most useful method to adopt to fulfil the quota of 20 venues, which would make the study one of the largest in the world.
- There was restricted access to venues after 01:00. However, the highest noise levels were expected between 00:30 to 01:00 (Whitfield, 1998).

- Ideally where a venue had more than one bar area a fixed position SLM could have been placed in each area. However, due to equipment limitations only one bar area was measured in each venue using octave band analysis.
- The enforcement officer questionnaires were completed by EHOs from Northern Ireland as it was not possible for the HSA to participate in the study at the time. The role of EHO in this jurisdiction is slightly different to their counterparts in the Republic of Ireland.
- It was not possible to report a 95% confidence interval for interview and questionnaires completed by management, employees or enforcement officers due to the low response rates. The enforcement officers response rate may have been lower than expected (57%) due to the holiday period (August). Low response rates from employees may be evidence of an unwillingness to take part in the research.
- Using focus groups means that the findings cannot be overly generalised even though focus groups allow probing of participants for more in-depth responses and opinions.

8.8 Future research

The following suggestions are areas that may warrant future research:

1. Examining the area of security personnel's noise exposure in further detail taking into account noise from earpiece radios.
2. Further research into the design features of nightclubs and the noise reduction achievable using new materials in venues.
3. Explore the cost of accidents related to glassware in the amplified music industry. Research to identify cost effective solutions and stakeholders barriers to switching to non-glass vessels.

4. Establish whether employees working in the smoking areas of venues experience temporary threshold shifts (TTS) more severely than their colleagues.
5. Lutman, Davis and Ferguson, 2008 recommended further research in the area of biomarkers from reduced otoacoustic emissions that could be predictive of future susceptibility to noise-induced hearing loss.

8.9 Concluding remarks

The overall aim of this thesis was to use components of risk analysis to guide an exploratory study to measure employees' noise exposure in Leinster entertainment venues, to examine compliance with the Noise Regulations 2007 and explore the reasons for non-compliance. This aim has been achieved by conducting one of the largest occupational noise studies in the world in this industry sector.

The most important outcomes from the study were the finding that the average nightclub bartenders' daily noise exposure ($L_{EX, 8h}$) was 92 dBA, almost four times more than the accepted legal limit. None of the venues examined were fully compliant with the requirements of the 2007 Noise Regulations and awareness of this legislation was limited. Hearing protection was only worn by employees in one venue. The training intervention led to a significant increase in employees' noise knowledge, but without managements encouragement hearing protection use did not significantly increase ($p > 0.05$).

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Appendix 1

Alignment of PhD objectives to the risk analysis objectives

Table A.1: The alignment of the six PhD objectives with the objectives described in the thesis related to the three aspects of noise risk analysis.

Aspect of risk analysis	PhD objective	Chapter objective
Noise risk assessment	To determine amplified late night music venues employees' daily and weekly noise exposures.	• Identify noise hazards. • Characterise noise hazard.
	Calculate the predicted hearing loss of employees based on their noise exposure.	• Characterise noise risk and effects.
Noise risk management	Determine venues level of compliance with the Noise Regulations, 2007 and adherence to the HSA guidance document "Noise of Music".	• Consideration of control options available. • Selection and implementation of controls.
	Explore the challenges faced by authorities when enforcing the requirements of the occupational noise legislation.	• Selection and implementation of controls.
Noise risk communication	Develop an effective noise awareness training programme that will target employee beliefs and barriers.	• Identify risk communication intervention objectives. • Engage in the exchange of information and opinions. • Develop noise training intervention. • Implementation of noise training intervention. • Measurement of immediate intervention outcome from increase in employee knowledge.
	Investigate the safety culture in venues and the reasons for non-compliance to the Noise Regulations, 2007.	• Measurement of intermediate intervention outcomes from increase in participation in management noise policies.

Appendix 2

Outline of the project made available online on the INIA website

TITLE OF RESEARCH: Occupational noise exposure in amplified music venues in Leinster: an exploratory risk analysis

RESEARCHER: The research is being carried out by full-time research PhD student Aoife Kelly, in the School of Food Science and Environmental Health, Cathal Brugha Street, Dublin Institute of Technology. This study will form part of a PhD research thesis.

Introduction

Recently the occupational noise legislation in Ireland was changed and the maximum occupational noise level experienced by employees was reduced. The noise legislation sets out specific requirements, for example noise risk assessments must be completed and control measures must be put in place.

Would you be interested in availing of a free noise risk assessment, if so, I am looking for interested managers to participate in the research. Please feel free to contact, Aoife Kelly by email on [redacted] or on [redacted].

Benefits of Research

Participating in this research may offer the following benefits to your premises;

- **Report** issued following risk assessment with **easy to understand guidance** on the requirements of the noise legislation and suggested control measures to reduce employee noise exposure.
- A chance for you to **express your opinions** on the noise legislation and put forward your suggestions on suitable noise controls for the industry.

Requirements of Research

Nightclub managers and employees are asked to participate in the study on a voluntary basis.

(i) Design Features of Nightclub Recorded:

If you enter into this study the researcher will need to visit your nightclub premises before it is open to the public. This is to record the distance of the bar(s) from the dance-floor, number of speakers and their locations and the presence of a sound limiter. This visit should last no longer than one hour.

(ii) Nightclub Noise Exposure:

If you enter into this study, you will be required to allow noise monitoring to take place over 3 nights, between the hours of 9pm-1am. This monitoring carried out using a sound level meter which is placed in the largest bar area of your nightclub. This sound level meter will be out of view of customers and a small extension cable shall be placed on a shelf behind your bar from 9-1am. In addition you will be required to allow the researcher to approach a consenting nightclub employee to wear a light-weight personal noise meter which records the level of noise. This noise meter will be attached to their collar. They will be given a demonstration on how to attach the noise meter.

(iii) Interviews and Questionnaires:

If you enter into this study you will be required to complete a short interview regarding attitudes and opinions of the change in the noise legislation and the control measures already in place to reduce employee noise exposure. Your staff will be requested to complete a separate questionnaire relating to attitudes to the use of hearing protection and experience of hearing troubles in their past. Each questionnaire is expected to take no longer than 10 minutes to complete.

Confidentiality

You, your employees or the nightclub will not be referred to by name in any of the documents relating to the PhD research. The data generated as a result of the research study shall be treated confidentially. Information collected about you, your employees or the nightclub premises will be kept strictly private and will not be disclosed to a third party. Data will only be used in the analysis for the research PhD purposes and future academic publications.

Refusal or Withdrawal without Penalty

Your taking part in this study is your choice. There will be no penalty if you decide not to participate. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with the researcher or the Dublin Institute of Technology institution.

Questions

If you wish to avail of these free risk assessments and noise measurements or have any additional questions please feel free to contact me, Aoife Kelly by email on [redacted]

Appendix 3

The venue manager structured interview

SECTION 1 — ABOUT YOU

GENDER: MALE ☐ FEMALE ☐ **AGE:** ☐ 18-25 ☐ 25-40 ☐ +40 PREFER NOT TO SAY ☐

JOB TITLE? ______________________ **NUMBER OF YEARS IN THIS ROLE:** __________

QUALIFICATIONS AND H&S TRAINING RECEIVED? ______________________

____

SECTION 2 — ABOUT THE NIGHTCLUB

FROM INTERVIEW WITH MANAGER

TRADING HOURS:

MON: ________ TUES: ________ WED: ________ THURS: ________ FRI: ________ SAT: ________ SUN: ________

PATRON CAPACITY: ☐ < 200 ☐ 200-500 ☐ 500-1000 ☐ + 1000

NO. OF EMPLOYEES: FULL-TIME________ PART-TIME ________

TYPE OF MUSIC: ☐ POP/MODERN ☐ ROCK ☐ DANCE/RAVE

☐ OTHER ______________________

OBSERVED BY RESEARCHER

TYPE OF PREMISES

☐ NIGHTCLUB

☐ NIGHTCLUB IN HOTEL

☐ NIGHTCLUB ABOVE/BELOW BAR

☐ OTHER______________________

LOCATION OF PREMISES

☐ CITY CENTRE

☐ URBAN

☐ TOWN

☐ OTHER ______________________

OTHER OBSERVATIONS:

____

____

SECTION 3 — NIGHTCLUB DESIGN

NO. OF BARS: _____ **NO. OF LEVELS:** ________ **DANCE-FLOORS:** ____________

CAN YOU CONTROL THE VOLUME OF THE SPEAKERS INDIVIDUALLY AT THE BAR AREA?

☐ YES ☐ NO ☐ DON'T KNOW

HOW OLD IS THE SOUND SYSTEM? ________ *COST OF THE SOUND SYSTEM?* ________

IS MAINTENANCE CARRIED OUT ON SOUND EQUIPMENT? ☐YES ☐NO ☐DON'T KNOW

HOW OFTEN IS IN A YEAR IS MAINTENANCE CARRIED OUT ON THE SOUND EQUIPMENT? __________

How are the checks carried out? ______________________________

Who carries out the checks? ______________________________

What training have they received? ______________________________

Do DJ's and performers add to the existing in-house speakers?

☐ Yes ☐ No ☐ Don't Know

If yes, what controls did the manager put in place? ______________________________

____

Is there a sound/noise limiter? ☐ Yes ☐ No ☐ Don't Know

If yes, when was it installed? ______________________________

Do you have any of the following?
☐ User manual for sound system/speakers
☐ Specification sheets for material used in the venue?

Section 4 GENERAL HEALTH AND SAFETY

Q1 Is there a safety statement? ☐ Yes ☐ No ☐ Don't Know *If yes, is there an annual review of the safety statement?* ______________	**Q1 Has a safety statement been observed?** ☐ Yes ☐ No
Q2 Is there an accident/incident logbook? ☐ Yes ☐ No ☐ Don't Know	**Q2 Has an accident/incident logbook been Observed?** ☐ Yes ☐ No
Q3 Are there noise risk assessments? ☐ Yes ☐ No ☐ Don't Know	**Q3 Has a noise risk assessment(s) been Observed?** ☐ Yes ☐ No

IF NIGHTCLUB HAS NO NOISE RISK ASSESSMENT, MOVE TO QUESTION 5.

If yes, who carried the noise risk assessment out?

☐ *Consultant* ☐ *In-house* ☐ *Other* ______________

What equipment was used? ______________________________

What training did the tester receive? ______________________________

What procedure was used? ______________________________

When was it carried out? ______________________________

When is the next review of the noise risk assessment due? ______________

Q4 Were staff consulted in relation to the noise risk assessment?

☐ YES ☐ NO ☐ DON'T KNOW

*IF YES, HOW WERE THEY CONSULTED?*___________________________________

SECTION 5 COMPLIANCE WITH REQUIREMENTS SET OUT IN THE NOISE LEGISLATION

Q5 ARE NOISE LEVELS RECORDED BY NIGHTCLUB?

☐ YES ☐ NO ☐ DON'T KNOW

IF YES, HOW OFTEN ARE NOISE LEVELS RECORDED?

____

ARE THERE SET REFERENCE POSITIONS?

☐ YES ☐ NO ☐ DON'T KNOW

IF YES, WHERE ARE THESE POSITIONS IN THE NIGHTCLUB? __________________

____

WHAT LEVELS HAVE BEEN RECORDED ON THE?

☐ DANCE FLOOR _______DB

☐ BAR _______DB

☐ SEATING AREA _______DB

☐ OTHER _______DB

Q6 IS THERE INFORMATION AVAILABLE ON THE SOUND SYSTEM IN PLACE?

☐ YES ☐ NO ☐ DON'T KNOW

Q4 DOES THE RISK ASSESSMENT HIGHLIGHT:

☐ LEVEL OF NOISE _______________

☐ TYPE OF NOISE _______________

☐ DURATION OF NOISE __________

☐ EXPOSURE LIMIT VALUE

☐ UPPER EXPOSURE ACTION VALUE

☐ LOWER EXPOSURE ACTION VALUE

☐ POTENTIAL EFFECTS OF NOISE ON EMPLOYEE HEARING

Q5 ACCORDING TO THE NOISE RISK ASSESSMENT WHAT CONTROL MEASURES HAVE BEEN PUT IN PLACE?

1 ____________________________

2 ____________________________

3 ____________________________

Q7 ARE STAFF PROVIDED WITH HEARING PROTECTION I.E. EARPLUGS OR EARMUFFS? ☐ YES ☐ NO ☐ DON'T KNOW

IF YES, WHO SELECTED THEM ____

DO YOU KNOW HOW THEY WERE SELECTED?? ____________________________________

WERE EMPLOYEES INSTRUCTED ON HOW TO FIT HEARING PROTECTION PROPERLY?

☐ YES ☐ NO ☐ DON'T KNOW

Q8 WHO HAS CONTROL OF THE NOISE LEVELS IN THE NIGHTCLUB?

☐ DJ'S ☐ GLASS CLEANERS ☐ BAR STAFF ☐ OTHER__________

Q9 HAVE THOSE IN CONTROL OF NOISE LEVELS IN THE NIGHTCLUB BEEN TRAINED ON THE CORRECT WAY TO USE THE SOUND EQUIPMENT?

☐N/A	DJ'S	☐ YES	☐ NO	☐ DON'T KNOW
☐N/A	GLASS CLEANERS	☐ YES	☐ NO	☐ DON'T KNOW
☐N/A	BAR STAFF	☐ YES	☐ NO	☐ DON'T KNOW
☐N/A	OTHER	☐ YES	☐ NO	☐ DON'T KNOW

Q10 HAVE EMPLOYEES BEEN TRAINED ABOUT NOISE AND THE RISK OF HEARING LOSS?

☐ YES ☐ NO ☐ DON'T KNOW

IF YES, DID THE TRAINING COVER THE FOLLOWING?

- ☐ *EXISTENCE OF NOISE LEGISLATION?*
- ☐ *CHANGES IN THE NEW NOISE LEGISLATION IN COMPARRISON TO THE OLD LEGISLATION?*
- ☐ *WHERE NOISE IS GENERATED AND IS S A RISK IN THE NIGHTCLUB?*
- ☐ *REASONS FOR ORGANISATIONAL MEASURES TO HELP COMPLY WITH NOISE LEGISLATION?*
- ☐ *REASONS FOR TECHNICAL MEASURES TO HELP COMPLY WITH NOISE LEGISLATION?*
- ☐ *NOISE LEVELS MEASURED IN THE NIGHTCLUB?*
- ☐ *EFFECTS NOISE MAY HAVE ON EMPLOYEE HEARING?*
- ☐ *HOW TO USE HEARING PROTECTION PROPERLY?*
- ☐ *HOW TO REPORT A HEARING PROBLEM OR RINGING BUZZING IN EARS AFTER WORKING IN THE NIGHTCLUB?*

*WHO DEVELOPED THE TRAINING PROGRAMME?*______________________________

Q11 HAVE EMPLOYEES HAD THEIR HEARING TESTED?

☐ YES ☐ NO ☐ DON'T KNOW

IF YES, WHEN DID THIS START? ______________ *HOW OFTEN IS IT CHECKED?* ____________

ARE HEALTH FILES KEPT FOR THE EMPLOYEES? ☐YES ☐ NO ☐DON'T KNOW

WHEN ARE HEARING TESTS CARRIED OUT?

☐ *BEFORE COMMENCING EMPLOYMENT* ☐ *WITHIN 12 MONTHS OF EMPLOYMENT AND EVERY 5 YRS AFTER THAT*

☐ *OTHER* ______________________________

WHAT TESTS WERE CARRIED OUT TO TEST THE EMPLOYEES HEARING?

☐ *PURE-TONE AUDIOMETRIC TESTING* ☐ *SELF-ASSESSMENT + TINNITUS ASSESSMENT*

☐ *OTHER* ______________________________

WHO CONDUCTED THE TESTS?

☐ *EXTERNALLY*	☐ *INTERNALLY*
HOW WERE THEY SOURCED? ______	*WHAT EQUIPMENT WAS USED?* ______
WHAT WAS THEIR QUALIFICATIONS? ______	*WHAT TRAINING HAS THE TESTER RECEIVED?* ______
WAS THE TEST COMPLETED ☐ *ON-SITE?* ☐ *EXTERNAL OFFICE*	*WHAT IS THE PROCEDURE USED?* ______

SECTION 6 MANAGEMENT AND MISCELLANEOUS QUESTIONS

Q12 HOW MANY HOURS ON AVERAGE DO EMPLOYEES WORK IN A WEEK?

NO. OF FULL-TIME EMPLOYEES ______ ***HOURS WORKED?*** ______

NO. OF PART-TIME EMPLOYEES ______ ***HOURS WORKED?*** ______

Q13 IS THERE A STAFF ROTATION SYSTEM IN PLACE I.E. MOVED FROM BAR TO CLOAKROOM? ☐ YES ☐ NO ☐ DON'T KNOW

IF YES, PLEASE GIVE EXAMPLES OF HOW LONG EMPLOYEES ARE WORKING IN THE CLOAKROOM? ______

HOW EFFECTIVE YOU FIND IT TO BE IN LOWERING EMPLOYEES NOISE EXPOSURE?

______

Q14 IS ANY CONSIDERATION IS GIVEN TO THE EMPLOYEE ROSTER IN RELATION TO GAPS IN DAYS OFF? ☐ YES ☐ NO ☐ DON'T KNOW

IF YES, WHAT CONSIDERATION IS GIVEN? ______

Q15 HAVE YOU EVER HAD AN INSPECTION BY THE HEALTH AND SAFETY AUTHORITY?

☐ YES ☐ NO ☐ DON'T KNOW

IF YES, DID THEY ASSESS THE NOISE LEVELS EMPLOYEES WERE EXPOSED TO?

☐ YES ☐ NO ☐ DON'T KNOW

Q16 HAVE THE HSA EVER GIVEN YOU GUIDANCE IN RELATION TO THE NOISE LEGISLATION? ☐ YES ☐ NO ☐ DON'T KNOW

IF YES, DID YOU: ☐ ***CONTACT THEM YOURSELF*** ☐ ***LOOK UP THE HSA WEBSITE*** ☐ ***IN THE POST***

☐ ***OTHER*** ______

SECTION 7 OPINIONS, ATTITUDES AND KNOWLEDGE TO NOISE IN THE WORKPLACE

Q17 **ARE YOU FAMILIAR WITH SOUND LIMITER DEVICES?** ☐ YES ☐NO ☐DON'T KNOW

A SOUND LIMITER IS A DEVICE WHICH IS ATTACHED TO THE MAIN POWER SUPPLY OF AN AMPLIFICATION UNIT IN THE NIGHTCLUB. IF THE MUSIC LEVEL EXCEEDS A PRESET SOUND LEVEL A LIGHT MAY FLASH TO WARN THE OPERATOR TO TURN DOWN THE VOLUME. IF THE WARNING LIGHT IS IGNORED THE MUSIC WILL AUTOMATICALLY CUT OFF FROM THE POWER SOURCE.

WHAT ARE YOUR OPINIONS ON SOUND LIMITERS?____

Q18 **WHAT IN YOUR OPINION ARE THE 3 BEST WAYS TO REDUCE THE NOISE LEVELS EMPLOYEES EXPERIENCE IN THE NIGHTCLUB?** PLEASE GIVE REASONS FOR YOUR ANSWERS?

- ____
- ____
- ____

Q19 **WOULD YOU EVER CONSIDER HANGING SIGNS WHICH HIGHLIGHT THE NOISE LEVELS IN DIFFERENT AREAS OF THE NIGHTCLUB?** ☐ YES ☐NO ☐DON'T KNOW

WHY WOULD YOU CONSIDER IT/WHY WOULD YOU NOT CONSIDER IT? BENEFITS OR DRAW BACKS FROM THIS?________________________________

Q20 **HAVE YOU EVER CONSIDERED PROVIDING HEARING PROTECTION TO NIGHTCLUB PATRONS?** ☐ YES ☐ NO ☐ DON'T KNOW

WHY WOULD YOU CONSIDER IT/WHY WOULD YOU NOT CONSIDER IT? BENEFITS OR DRAW BACKS FROM THIS________________________________

Q21 **DO YOU THINK IT IS IMPORTANT TO AVOID NOISE COMPLAINTS FROM**

☐ NEIGHBOURS/RESIDENTS? ☐ BOTH

☐ STAFF/PATRONS? ☐ NEITHER

Q22 **HAVE YOU EVER HEARD OF LEGISLATION FOR REDUCING THE NOISE EMPLOYEES ARE EXPOSED TO?** ☐ YES ☐ NO *(IF NO, PLEASE GO TO Q 24)*

CAN YOU NAME THE TITLE OF THE NOISE LEGISLATION? ☐ YES ☐NO ☐DON'T KNOW

IF YES (PLEASE STATE NAME OF LEGISLATION HERE)________________________

Q23 **IN WHAT YEAR WAS THE NOISE LEGISLATION INTRODUCED INTO NIGHTCLUBS?**

☐ 2002 ☐ 2004 ☐ 2006 ☐ 2008 ☐ DON'T KNOW

Sound is measured in decibels (dB).

Q24 **Sounds measuring over ________ can be damaging to human hearing.**

Please choose from the following options.

☐ 75 decibel ☐ 100 decibels ☐ 1000 decibels ☐ Don't Know

Q25 **There is a decibel level at which employers provide earplugs for staff who ask for them. Do you know what that level is?**

☐ Yes (*if yes, please state level here*)________ ☐No ☐Don't Know

Q26 **There is a decibel level that requires employees wear earplugs if the noise level is exceeded. Do you know what that decibel level is?**

☐ Yes (*if yes, please state level here*)________ ☐No ☐Don't Know

Q27 **In an 8 hour day employees are not supposed to be exposed to noise over a certain decibel level. Do you know what that decibel level is?**

☐ Yes (*if yes, please state level here*)________ ☐No ☐Don't Know

Q28 **If the maximum decibel level was exceeded in the nightclub what would you do to reduce the noise level?** (*Grade from 1-5, 1 indicates the first measure you would take, 5 indicates the last measure*).

_____ Supply ear plugs to employees

_____ Turn the music volume down

_____ Rotate staff from noisy areas to less noisy areas

_____ Install a sound limiter dev ice

_____ Redecorate the nightclub with materials which absorb noise

Q29 **Please name 3 effects listening to loud sounds on a daily basis can have on your health?**

- ____
- ____
- ____

Q30 **There is a decibel level that requires employee have their hearing tested. Do you know what that decibel level is?**

☐ Yes (*if yes, please state level here*)_____ ☐ No ☐ Don't Know

Q31 **There is a decibel level that requires employee hearing tests are done by a medical person. Do you know what that decibel level is?**

☐ YES (*IF YES, PLEASE STATE LEVEL HERE*)_____ ☐ NO ☐ DON'T KNOW

Q32 HAVE ANY EMPLOYEES BEEN ABSENT FROM WORK AS A RESULT OF A HEARING RELATED ILLNESS? ☐ YES _________ ☐ NO ☐ DON'T KNOW

Q33 HAS THE NIGHTCLUB EVER BEEN ASKED TO TURN THE MUSIC VOLUME UP?

☐YES ☐NO ☐DON'T KNOW

IF YES PLEASE GIVE DETAILS E.G. CUSTOMER, DJ ETC. AND WHAT ACTION THE NIGHTCLUB TOOK I.E. TURNED IT UP A LITTLE OR A LOT ____

Q34 HAS THE NIGHTCLUB EVER BEEN ASKED TO TURN THE MUSIC VOLUME DOWN?

☐YES ☐NO☐DON'T KNOW

*IF YES PLEASE GIVE DETAILS E.G. CUSTOMER, DJ ETC. AND WHAT ACTION THE NIGHTCLUB TOOK I.E. DID NOTHING, TURNED IT DOWN A LITTLE OR A LOT*___________________________

WHAT DO YOU THINK ARE THE MOST IMPORTANT ISSUES A NIGHTCLUB DEALS WITH?

1. ____
2. ____
3. ____
4. ____
5. ____

WHAT IS YOUR EXPERIENCE OF NOISE IN THE WORKPLACE?

____

____

____

IN LEGISLATION MAXIMUM NOISE LEVELS EMPLOYEES ARE EXPOSED TO IN THE WORKPLACE HAVE BEEN REDUCED. IN YOUR OPINION WHAT SPECIFIC CHALLENGES DO YOU THINK THE NIGHTCLUB INDUSTRY HAVE IN RELATION TO CONTROLLING NOISE?

____

____

____

DO YOU FEEL YOU WOULD BENEFIT IF EMPLOYEES WERE PROVIDED TRAINING ON NOISE AND ITS EFFECTS? PLEASE GIVE A REASON FOR YOUR ANSWER.

☐ **YES** ☐ **NO** ☐ **DON'T KNOW**

____

____

Appendix 4

The venue employee noise questionnaire

SECTION 1 ABOUT YOU

GENDER: MALE ☐ FEMALE ☐ **AGE:** ______ PREFER NOT TO SAY ☐

WHICH ONE OF THE FOLLOWING BEST DESCRIBES YOUR JOB TITLE IN THE NIGHTCLUB?

☐ BAR STAFF ☐ GLASS COLLECTOR

☐ SECURITY ☐ OTHER (PLEASE DESCRIBE) ____________

TICK ALL THE DUTIES BELOW YOU CARRY OUT AS PART OF YOUR JOB AND HOW LONG APPROXIMATELY IN HOURS YOU SPEND AT EACH OF THESE JOBS ON AN AVERAGE WORKING NIGHT IN THE NIGHTCLUB.

FOR EXAMPLE √ ***BAR WORK 3 HOURS*** + √ ***COLLECTING GLASSES 1 HOUR***

☐ STOCK-TAKING OUT OF HOURS __HRS ☐ DISPOSING OF GLASS BOTTLES __HRS

☐ CLEANING OUT OF HOURS __HRS ☐ SECURITY ON DANCEFLOOR __HRS

☐ WORKING BEHIND BAR WHEN NIGHTCLUB IS OPEN __HRS ☐ SECURITY AT OUTSIDE DOORS TO NIGHTCLUB __HRS

☐ COLLECTING GLASSES __HRS ☐ TICKET SALES /CLOAKROOM __HRS

☐ WORK IN ANOTHER BAR BEFORE NIGHTCLUB OPENS __HRS OTHER (*PLEASE SPECIFY*) ________________________ __HRS

HOW LONG HAVE YOU WORKED IN THE NIGHTCLUB INDUSTRY? ___________ YEARS

HOW MANY HOURS DO YOU CURRENTLY WORK PER WEEK IN THE NIGHTCLUB? _ HOURS

DO YOU HAVE A SECOND JOB WITH ANOTHER EMPLOYER? ☐ YES ☐ NO

IF YES, PLEASE SPECIFY WHAT OTHER JOB YOU HAVE ______________________________

AND THE NUMBER OF HOURS WORKED PER WEEK _________________________________

HOW MANY BREAKS DO YOU TAKE DURING YOUR SHIFT IN THE NIGHTCLUB?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ +5

*HOW LONG DO YOUR BREAKS LAST FOR?*____

WHEN WORKING IN THE NIGHTCLUB WHERE DO YOU TAKE YOUR BREAKS? ________________

DO YOU HAVE A PERSONAL STEREO/MP3/IPOD? ☐ YES ☐ NO

IF YES, APPROXIMATELY HOW MANY HOURS DO YOU LISTEN TO IT A WEEK? ___________ HOURS

SECTION 2 HEARING SELF-ASSESSMENT

Q1 HAVE YOU EVER HAD YOUR HEARING TESTED? ☐ YES ☐ NO ☐ DON'T KNOW

IF YES, WHERE WAS IT TESTED? ☐ WITH CURRENT EMPLOYER

☐ WITH A PREVIOUS EMPLOYER ☐ PERSONALLY WENT FOR TEST

Q2 HAS A DOCTOR OR MEDICAL PROFESSIONAL EVER DIAGNOSED THAT YOU HAD A HEARING PROBLEM? ☐ YES ☐ NO ☐ DON'T KNOW

If yes, what was the diagnosis? ____________________

Q3 Have you ever been in military service? ☐ Yes ☐ No

Q4 Have you ever experienced any type of hearing related problems such as ear-disease, ringing/buzzing in ears or difficulty in hearing?

☐ Yes ☐ No (*if no, please go to Q6*)

Q5 Exactly what type of hearing related problem did you experience?
(*More than one option may be ticked*)

☐ Ear Disease/Infection ☐ Trouble Hearing
☐ Ringing or buzzing in ears ☐ Ear related dizziness

To your knowledge, what caused this problem(s)? ____________________

Q6 Have you ever experienced any type of hearing-related problems in these settings? *For Example ringing/buzzing in ears or difficulty in hearing?*

	Yes	No
Listening to music on a personal stereo/MP3?	☐	☐
During/after going to a concert?	☐	☐
During/After working in this nightclub?	☐	☐
During/after going to another nightclub?	☐	☐

Q7 How often have you experienced hearing related problems in these setting?

	Always	Usually	Sometimes	Rarely	Never
Listening to music on a personal stereo/MP3?	☐	☐	☐	☐	☐
During/after going to a concert?	☐	☐	☐	☐	☐
During/After working in this nightclub?	☐	☐	☐	☐	☐
During/after going to another nightclub?	☐	☐	☐	☐	☐

Q8 Have you ever experienced ringing/buzzing in your ears after participating in the following activities? *Please tick* <u>*all*</u> *that apply and how many hours a* <u>*week*</u> *you spend at these activities.*

☐	Motor-sport Events	__Hrs	☐	Riding Motorbikes or Quads	__Hrs
☐	Shooting	__Hrs	☐	Video arcades	__Hrs

	☐ OTHER *(PLEASE SPECIFY)* ______________________ __HRS						
Q9	**HAVE YOU EVER WORKED IN THE FOLLOWING TYPES OF OCCUPATIONS?** *PLEASE TICK AS MANY BOXES THAT APPLY TO YOUR WORK HISTORY AND INDICATE LENGTH OF TIME IN YEARS IN THAT EMPLOYMENT.*						
☐	LOGGING/LUMBER INDUSTRY	___YEARS	☐	TRANSPORTATION	___YEARS		
☐	MINING	___YEARS	☐	CONSTRUCTION	___YEARS		
☐	FARMING	___YEARS	☐	GARDAÍ	___YEARS		
☐	CANNING FACTORY	___YEARS	☐	PRINTING	___YEARS		
☐	OTHER*(PLEASE SPECIFY)* ______________	___YEARS	☐	NIGHTCLUBS	___YEARS		
Q10	**DO YOU HAVE ANY DIFFICULTIES HEARING EVERYDAY CONVERSATION?**						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
	IF YOU DO HAVE DIFFICULTIES HEARING, PLEASE DESCRIBE THE DIFFICULTIES YOU ARE HAVING ______________________						
Q11	**DO YOU HAVE A PROBLEM HEARING OVER THE TELEPHONE?**						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
Q12	**DO YOU HAVE TROUBLE FOLLOWING CONVERSATION WHEN MORE THAN ONE PERSON IS TALKING**						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
Q13	**DO PEOPLE COMPLAIN THAT YOU TURN THE TV VOLUME UP TOO HIGH?**						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
Q14	**DO YOU HAVE TROUBLE HEARING IF THERE IS LOUD MUSIC ON IN THE BACKGROUND?**						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
Q15	**DO YOU HAVE DIFFICULTY HEARING CO-WORKERS/CUSTOMERS WHEN THE NIGHTCLUB MUSIC IS ON?**						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
Q16	**DO YOU FIND YOURSELF ASKING PEOPLE TO REPEAT THEMSELVES?**						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
Q17	**DO YOU HAVE RINGING, BUZZING OR TINNITUS IN YOUR EARS?**						
	☐ YES ☐ NO*(IF NO, MOVE TO Q 22)*						
	IF YES, DO YOU HAVE RINGING, BUZZING OR TINNITUS IN YOUR EAR(S):						
	☐ ALWAYS	☐ USUALLY	☐ SOMETIMES	☐ RARELY	☐ NEVER		
	HOW LONG AGO DID THE RINGING, BUZZING OR TINNITUS BEGIN? ________ YEARS						

Is the ringing, buzzing or tinnitus in the left, right or both ears?

☐ Left ☐ Right ☐ Both

Q18 Have you ever had a significant head or neck injury? ☐ Yes ☐ No

Did the ringing, buzzing or tinnitus start as a result of this injury?

☐ Yes ☐ No

Q19 Did you become aware of your tinnitus?

☐ Suddenly ☐ Gradually ☐ Don't Know

Q20 How often do you have tinnitus?

☐ Daily ☐ Weekly ☐ Monthly ☐ Constantly ☐ After Work ☐ Other *(please specify)*____

Q21 List what you think may have caused your tinnitus. *Examples may include cold or other illness, ear infection, ear or head injury, exposure to loud noise,etc.*____

Section 3 Opinions, Attitudes and Knowledge of Noise

Q22 Have you ever worn ear plugs or ear muffs in the past? ☐ Yes ☐ No

*If yes, please state where*____

Q23 If provided by your employer, would you wear hearing protection e.g. ear plugs? ☐ Yes ☐ No ☐ Don't Know

Please give a reason for your answer: ____

Q24 Please answer the following by ticking either box:

	True	**False**
There is no right or wrong way to insert earplugs.	☐	☐
Wearing suitable ear plugs can save your hearing from damage to loud noise.	☐	☐
In the nightclub ear plugs should be worn when you are not able to hear what someone is saying when standing at arms length.	☐	☐
Ear plugs that have gone very hard after use or are cracked are ok to wear to protect hearing.	☐	☐
When inserting ear plugs they should not	☐	☐

	HAVE EAR WAX OR DUST ATTACHED TO THEM.		

Q25 **WHEN THE NIGHTCLUB MUSIC IS ON IS IT POSSIBLE TO HEAR WHAT A CO-WORKER IS SAYING IF THEY WERE STANDING AT ARMS LENGTH FROM YOU?**

☐ YES ☐ NO ☐ DON'T KNOW

Q26 **DOES YOUR NIGHTCLUB HAVE A SAFETY STATEMENT?**

☐YES ☐ NO ☐DON'T KNOW

IF YES, DO YOU HAVE A COPY OF THE SAFETY STATEMENT? ☐YES ☐NO ☐DON'T KNOW

Q27 **DOES YOUR NIGHTCLUB HAVE A RISK ASSESSMENT FOR NOISE?**

☐ YES ☐ NO ☐ DON'T KNOW

IF YES, WERE YOU EVER CONSULTED ON THE ISSUE OF NOISE IN THE WORKPLACE:

☐ YES ☐ NO ☐ DON'T REMEMBER

Q28 **HAVE YOU EVER BEEN TRAINED HOW TO CONTROL THE VOLUME FROM THE NIGHTCLUB SOUND SYSTEM?** ☐ YES ☐ NO ☐ DON'T REMEMBER

Q29 **DO YOU EVER GET ASKED TO CHANGE THE VOLUME OF THE MUSIC PLAYED IN THE NIGHTCLUB?** ☐YES ☐ NO ☐DON'T REMEMBER

Q30 **HAVE YOU EVER HEARD OF LEGISLATION FOR REDUCING THE NOISE EMPLOYEES ARE EXPOSED TO?** ☐ YES ☐ NO *(IF NO, PLEASE GO TO Q 32)*

CAN YOU NAME THE TITLE OF THE NOISE LEGISLATION? ☐YES ☐NO ☐DON'T KNOW

*IF YES (PLEASE STATE NAME OF LEGISLATION HERE)*______________________________

Q31 **IN WHAT YEAR WAS THE NOISE LEGISLATION INTRODUCED INTO NIGHTCLUBS?**

☐ 2002 ☐ 2004 ☐ 2006 ☐ 2008 ☐ DON'T KNOW

SOUND IS MEASURED IN DECIBELS (dB).

Q32 **SOUNDS MEASURING OVER _________ CAN BE DAMAGING TO HUMAN HEARING.** *PLEASE CHOOSE FROM THE FOLLOWING OPTIONS.*

☐ 75 DECIBELS ☐ 100 DECIBELS ☐ 1000 DECIBELS ☐ DON'T KNOW

Q33 **THERE IS A DECIBEL LEVEL AT WHICH EMPLOYERS HAVE EARPLUGS FOR STAFF WHO ASK FOR THEM. DO YOU KNOW WHAT THAT LEVEL IS?**

☐ YES (*IF YES, PLEASE STATE LEVEL HERE*)_______ ☐NO ☐ DON'T KNOW

Q34 **THERE IS A DECIBEL LEVEL THAT REQUIRES EMPLOYEES WEAR EARPLUGS IF THE NOISE LEVEL IS EXCEEDED. DO YOU KNOW WHAT THAT DECIBEL LEVEL IS?**

☐ YES (*IF YES, PLEASE STATE LEVEL HERE*)_______ ☐NO ☐ DON'T KNOW

Q35 **IN AN 8 HOUR DAY EMPLOYEES ARE NOT SUPPOSED TO BE EXPOSED TO NOISE OVER A CERTAIN DECIBEL LEVEL. DO YOU KNOW WHAT THAT DECIBEL LEVEL IS?**

☐ YES (*IF YES, PLEASE STATE LEVEL HERE*)______ ☐NO ☐ DON'T KNOW

Q36 WHAT WOULD YOU CONSIDER THE HAS THE LOUDEST SOUND?

☐NIGHTCLUB DANCEFLOOR ☐ ROCK CONCERT

☐ LISTENING TO YOUR MP3/IPOD WITH VOLUME UP TO MAXIMUM LEVEL

☐ ALL 3 OPTIONS ARE SIMILAR SOUND LEVELS

Q37 WHAT EFFECT DO YOU THINK LOUD MUSIC HAS ON YOUR HEARING?

PLEASE CHOOSE ONE OPTION. ☐ BENEFICIAL ☐ HARMFUL ☐ NO EFFECT

Q38 DO YOU THINK LOUD MUSIC HAS ANY OTHER EFFECT ON HEALTH?

☐ YES (*IF YES, PLEASE STATE LEVEL HERE*)______ ☐NO ☐ DON'T KNOW

Q39 HAS THE NIGHTCLUB EVER BEEN ASKED TO TURN THE MUSIC VOLUME UP?

☐ YES (*IF YES, PLEASE STATE LEVEL HERE*)______ ☐NO ☐ DON'T KNOW

WHO ASKED FOR THE MUSIC TO BE TURNED UP?

☐ CUSTOMER ☐ DJ

☐ NEIGHBOURS ☐ GARDAÍ

☐ OTHER ___________________________

WHAT ACTION DID THEY TAKE?

☐ TOOK NO ACTION?

☐ DON'T KNOW

☐ TURNED IT UP A LITTLE?

☐ TURNED IT UP A LOT?

Q40 HAS THE NIGHTCLUB EVER BEEN ASKED TO TURN THE MUSIC VOLUME DOWN?

☐YES ☐ NO (*IF NO/DON'T KNOW, PLEASE GO TO Q 40*) ☐DON'T KNOW

WHO ASKED FOR THE MUSIC TO BE TURNED DOWN?

☐ CUSTOMER ☐ DJ

☐ NEIGHBOURS ☐ GARDAÍ

☐ OTHER ___________________________

WHAT ACTION DID THEY TAKE?

☐ TOOK NO ACTION? ☐ DON'T KNOW

☐ TURNED IT DOWN A LITTLE?

☐ TURNED IT DOWN A LOT

WHAT DO YOU THINK ARE THE MOST IMPORTANT ISSUES A NIGHTCLUB DEALS WITH?

6. ____

7. ____

8. ____

9. ____

10. ____

WHAT IS YOUR EXPERIENCE OF NOISE IN YOUR WORKPLACE?

IN YOUR OPINION WHAT SPECIFIC CHALLENGES DO YOU THINK THE NIGHTCLUB INDUSTRY HAVE IN RELATION TO CONTROLLING NOISE?

DO YOU FEEL YOU WOULD BENEFIT IF YOU WERE PROVIDED TRAINING ON NOISE AND ITS EFFECTS? *PLEASE GIVE A REASON FOR YOUR ANSWER.*

☐ YES ☐ NO ☐ DON'T KNOW

Appendix 5

A sample of the Bruel and Kjaer calibration certificate

CERTIFICATE OF CALIBRATION

Date of Issue: 08 April 2009 Certificate Number: C0903169

UKAS CALIBRATION
0174

Page 1 of 12 Pages

Brüel & Kjær S&V A/S

Skodsborgvej 307. DK-2850 Nærum, Denmark
Tel: +45 45 800 500 Fax: +45 45 801 405
Email: ukservice@bksv.com

Approved Signatory

Henning Ploug

CALIBRATION OF:

Sound Level Meter	2238	No: 2524265
Microphone:	4188	No: 2526300
Associated Calibrator:	Brüel & Kjær 4231	No: 2528221
Calibrator Certificate	C0903163	Level: 94.03 dB SPL
Inventory ID:		
Date of receipt:	01 April 2009	
Date of calibration:	08 April 2009	

CUSTOMER:

Dublin Institute of Technology
Cathal Brugha Street
Thomas Lane Entrance
Dublin 1
Ireland

Customer Ref.: FI 1039651 & CB 1039670

CALIBRATION CONDITIONS:

Preconditioning:	12 hours at 23 °C	
Environment conditions:	Air temperature:	22,7 °C
	Air pressure:	100,7 kPa
	Relative Humidity:	46 %RH

SPECIFICATIONS:
The Sound Level Meter was calibrated according to the procedure given in BS7580: Part 1: 1997.

PROCEDURE:
The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System B&K 3630 with application software type 7763 and test collection 2238-4188-BZ7126

RESULTS:
Unless otherwise stated herein, the reported uncertainty is based upon a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. The uncertainties refer to the measured values only with no account being taken of the ability of the device under test to maintain its calibration.

CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No. 0174

Certificate Number:

C0903169

Summary

Preliminary Inspection (5.3)	**Passed**
Setting up (5.4)	**Passed**
General (5.5.1)	**Passed**
Self-generated noise (5.5.2)	**Passed**
Linearity, reference range SPL (5.5.3)	**Passed**
Linearity, reference range Leq (5.5.3)	**Passed**
Linearity, reference level measured in other ranges (5.5.3)	**Passed**
Linearity at range limits (5.5.3)	**Passed**
Frequency weighting A (5.5.4)	**Passed**
Frequency weighting C (5.5.4)	**Passed**
Frequency weighting Lin (5.5.4)	**Passed**
Time weighting Fast (5.5.5)	**Passed**
Time weighting Slow (5.5.5)	**Passed**
Peak response (5.5.6)	**Passed**
R.M.S. accuracy (5.5.7)	**Passed**
Time weighting I (5.5.8)	**Passed**
Time averaging (5.5.9)	**Passed**
Pulse range and sound exposure level (5.5.10 and 5.5.11)	**Passed**
Overload indication, Non-integrating (5.5.12)	**Passed**
Overload indication, Integrating (5.5.12)	**Passed**
Acoustic calibration at 1000 Hz (5.6.1)	**Passed**
Acoustic test at 125 and 8000 Hz (5.6.2)	**Passed**
Response to sound calibrator (5.6.3)	**Passed**

STATEMENT OF RESULT:
- THE SOUND LEVEL METER CONFORMS TO BS7580: PART1:1997 VERIFYING CONFORMANCE TO BS EN 60651:1994, BS EN 60804:1994 AND BS3539:1986.

Instruments used in the verification procedure were traceable to national standards. The method of acoustic calibration employed a standard sound pressure calibrator. The test results were corrected for the difference between the free field and pressure response of the microphone supplied. The uncertainty of the standard calibrator is not included in the applied tolerances. The instrument was calibrated without a windscreen, consult manufacturer's manual if using a windscreen. The upper limit of the primary indicator range is 10dB less than the corresponding indicator range. The sound level meter was manufactured in accordance with BSEN60651:1994 Type 1, and BSEN60804:1994 or BSEN60804:2001 Type 1 if an integrating meter, and has been pattern evaluated and approved by a European National Institute of Metrology.

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

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Note:

Measurements close to or at the upper limit of a measuring range may produce an overload indication.
Similarly measurements close to or at the lower limit of a measuring range may produce an underrange indication.
This is not to be interpreted as an error of the Sound Level Meter, but an indication that the signal has reached the limit of the measuring range.

Instruments

Category:	Type:	Manufacturer:	Serial No.:	Last Calibration date:	Traceable to:
Generator	Pulse Generator	Brüel & Kjær	2558896	06 April 2009	DANAK 307
AmplifierDivider	3111 Output Module	Brüel & Kjær	2481841	06 April 2009	DANAK 307
Voltmeter	DMM34970A	Agilent	MY44013679	29 September 2008	DANAK 22
Adaptor	WA0302A, 12 pF	Brüel & Kjær	2542863	26 September 2008	DANAK 22
Calibrator	4226	Brüel & Kjær	2560144	06 February 2009	DANAK 307

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

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Preliminary Inspection (5.3)

Inspection and control of instruments submitted for calibration and verification of instruments power supply by service engineer initials: LP.

Setting up (5.4)

Test and adjust sound level meter using the supplied calibrator.

Certificate Value of the associated calibrator	94.03	dB SPL
Coupler Free-field Correction	-0.15	dB
SPL before adjustment	94.00	dB SPL
SPL after adjustment	93.90	dB SPL

General (5.5.1)

Electrical tests have been performed with the microphone replaced by a capacitive adaptor.

Self-generated noise (5.5.2)

The self-generated noise has been measured using a shortcircuit on the input of the capacitive adaptor.
If 'underrange' indicated, the level was below the minimum measureable value.

	Measured [dB SPL]
Noise FW A	12.6
Noise FW C	16.5
Noise FW Lin	22.8

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

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Linearity, reference range SPL (5.5.3)

The Linearity of the Sound Level Meter has been tested relative to the reference sound pressure level as indicated on the reference range using a continuous sinusoidal signal Frequency of 4000 Hz.
If 'underrange' indicated, the level was below the minimum measureable value.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
94 dB Ref.	94.0	94.0	-0.2	0.2	0.0	0.12
50 dB Rel. Ref.	50.0	50.3	-0.7	0.7	0.3	0.40
51 dB Rel. Ref.	51.0	51.2	-0.7	0.7	0.2	0.40
52 dB Rel. Ref.	52.0	52.1	-0.7	0.7	0.1	0.40
53 dB Rel. Ref.	53.0	53.1	-0.7	0.7	0.1	0.40
54 dB Rel. Ref.	54.0	54.1	-0.7	0.7	0.1	0.40
55 dB Rel. Ref.	55.0	55.1	-0.7	0.7	0.1	0.40
59 dB Rel. Ref.	59.0	59.1	-0.7	0.7	0.1	0.40
64 dB Rel. Ref.	64.0	64.0	-0.7	0.7	0.0	0.40
69 dB Rel. Ref.	69.0	69.0	-0.7	0.7	0.0	0.40
74 dB Rel. Ref.	74.0	74.0	-0.7	0.7	0.0	0.40
79 dB Rel. Ref.	79.0	79.0	-0.7	0.7	0.0	0.40
84 dB Rel. Ref.	84.0	83.9	-0.7	0.7	-0.1	0.40
89 dB Rel. Ref.	89.0	89.0	-0.7	0.7	0.0	0.40
99 dB Rel. Ref.	99.0	98.9	-0.7	0.7	-0.1	0.40
104 dB Rel. Ref.	104.0	104.0	-0.7	0.7	0.0	0.40
109 dB Rel. Ref.	109.0	108.9	-0.7	0.7	-0.1	0.40
114 dB Rel. Ref.	114.0	113.9	-0.7	0.7	-0.1	0.40
119 dB Rel. Ref.	119.0	118.9	-0.7	0.7	-0.1	0.40
124 dB Rel. Ref.	124.0	123.9	-1.0	1.0	-0.1	0.40
125 dB Rel. Ref.	125.0	124.9	-1.0	1.0	-0.1	0.40
126 dB Rel. Ref.	126.0	125.9	-1.0	1.0	-0.1	0.40
127 dB Rel. Ref.	127.0	126.8	-1.0	1.0	-0.2	0.40
128 dB Rel. Ref.	128.0	127.8	-1.0	1.0	-0.2	0.40
129 dB Rel. Ref.	129.0	128.8	-1.0	1.0	-0.2	0.40
130 dB Rel. Ref.	130.0	129.8	-1.0	1.0	-0.2	0.40

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

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Linearity, reference range Leq (5.5.3)

	Expected [dB Leq]	Measured [dB Leq]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]	
94 dB Ref.	94.0	93.9	-0.2	0.2	-0.1	0.12	
50 dB Rel. Ref.	49.9	---	-0.7	0.7	---	0.40	Underrange
51 dB Rel. Ref.	50.9	50.8	-0.7	0.7	-0.1	0.40	
52 dB Rel. Ref.	51.9	51.8	-0.7	0.7	-0.1	0.40	
53 dB Rel. Ref.	52.9	52.9	-0.7	0.7	0.0	0.40	
54 dB Rel. Ref.	53.9	54.0	-0.7	0.7	0.1	0.40	
55 dB Rel. Ref.	54.9	55.0	-0.7	0.7	0.1	0.40	
59 dB Rel. Ref.	58.9	59.0	-0.7	0.7	0.1	0.40	
64 dB Rel. Ref.	63.9	63.9	-0.7	0.7	0.0	0.40	
69 dB Rel. Ref.	68.9	68.9	-0.7	0.7	0.0	0.40	
74 dB Rel. Ref.	73.9	73.9	-0.7	0.7	0.0	0.40	
79 dB Rel. Ref.	78.9	78.9	-0.7	0.7	0.0	0.40	
84 dB Rel. Ref.	83.9	83.9	-0.7	0.7	0.0	0.40	
89 dB Rel. Ref.	88.9	88.9	-0.7	0.7	0.0	0.40	
99 dB Rel. Ref.	98.9	98.9	-0.7	0.7	0.0	0.40	
104 dB Rel. Ref.	103.9	103.9	-0.7	0.7	0.0	0.40	
109 dB Rel. Ref.	108.9	108.9	-0.7	0.7	0.0	0.40	
114 dB Rel. Ref.	113.9	113.9	-0.7	0.7	0.0	0.40	
119 dB Rel. Ref.	118.9	118.8	-0.7	0.7	-0.1	0.40	
124 dB Rel. Ref.	123.9	123.8	-0.7	0.7	-0.1	0.40	
125 dB Rel. Ref.	124.9	124.8	-0.7	0.7	-0.1	0.40	
126 dB Rel. Ref.	125.9	125.8	-0.7	0.7	-0.1	0.40	
127 dB Rel. Ref.	126.9	126.8	-0.7	0.7	-0.1	0.40	
128 dB Rel. Ref.	127.9	127.8	-0.7	0.7	-0.1	0.40	
129 dB Rel. Ref.	128.9	128.7	-0.7	0.7	-0.2	0.40	
130 dB Rel. Ref.	129.9	129.7	-0.7	0.7	-0.2	0.40	

Linearity, reference level measured in other ranges (5.5.3)

	Expected [dB LEQ]	Measured [dB LEQ]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
94 dB Range 130 Ref	94.0	93.9	-0.2	0.2	-0.1	0.12
94 dB Range 140	93.9	93.9	-0.7	0.7	0.0	0.40
94 dB Range 120	93.9	93.9	-0.7	0.7	0.0	0.40
94 dB Range 110	93.9	93.8	-0.7	0.7	-0.1	0.40
94 dB Range 100	93.9	93.8	-0.7	0.7	-0.1	0.40

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

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Linearity at range limits (5.5.3)

The lower limit may be affected by the noise as measured in 5.5.2

	Expected [dB LEQ]	Measured [dB LEQ]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
94 dB Ref.	94.0	93.9	-0.2	0.2	-0.1	0.12
Range 140, Lev 138	137.9	137.8	-0.7	0.7	-0.1	0.40
Range 140, Lev 62	61.9	61.8	-0.7	0.7	-0.1	0.40
Range 120, Lev 118	117.9	117.8	-0.7	0.7	-0.1	0.40
Range 120, Lev 42	41.9	41.8	-0.7	0.7	-0.1	0.40
Range 110, Lev 108	107.9	107.7	-0.7	0.7	-0.2	0.40
Range 110, Lev 32	31.9	31.8	-0.7	0.7	-0.1	0.40
Range 100, Lev 98	97.9	97.8	-0.7	0.7	-0.1	0.40
Range 100, Lev 22	28.5	28.7	-0.7	0.7	0.2	0.40
Range 90, Lev 88	87.9	87.7	-0.7	0.7	-0.2	0.40
Range 90, Lev 12	28.5	28.6	-0.7	0.7	0.1	0.40
Range 80, Lev 78	77.9	77.8	-0.7	0.7	-0.1	0.40
Range 80, Lev 2	28.5	28.6	-0.7	0.7	0.1	0.40

Frequency weighting A (5.5.4)

The frequency weighting has been tested at octave intervals from 31.5 Hz to 12.5kHz relative to 1000 Hz at the specified reference level. The measured values have been corrected for the effect of body influence and the frequency response of the microphone.

	Expected [dB SPL]	Measured [dB SPL]	Corr. Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
1000Hz Ref.	94.0	94.0	94.0	-0.2	0.2	0.0	0.12
31.623Hz	54.6	54.8	55.2	-1.5	1.5	0.6	0.20
63.096Hz	67.8	67.8	68.1	-1.5	1.5	0.3	0.20
125.89Hz	77.9	77.9	78.1	-1.0	1.0	0.2	0.20
251.19Hz	85.4	85.3	85.6	-1.0	1.0	0.2	0.20
501.19Hz	90.8	90.7	90.9	-1.0	1.0	0.1	0.20
1995.3Hz	95.2	95.2	95.2	-1.0	1.0	0.0	0.20
3981.1Hz	95.0	95.0	95.1	-1.0	1.0	0.1	0.20
7943.3Hz	92.9	92.9	93.1	-3.0	1.5	0.2	0.20
12589Hz	89.7	89.7	90.0	-6.0	3.0	0.3	0.20

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

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Frequency weighting C (5.5.4)

	Expected [dB SPL]	Measured [dB SPL]	Corr. Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
1000Hz Ref.	94.0	93.9	93.9	-0.2	0.2	-0.1	0.12
31.623Hz	90.9	91.2	91.6	-1.5	1.5	0.7	0.20
63.096Hz	93.1	93.2	93.5	-1.5	1.5	0.4	0.20
125.89Hz	93.7	93.8	94.0	-1.0	1.0	0.3	0.20
251.19Hz	93.9	93.9	94.2	-1.0	1.0	0.3	0.20
501.19Hz	93.9	94.0	94.2	-1.0	1.0	0.3	0.20
1995.3Hz	93.7	93.8	93.8	-1.0	1.0	0.1	0.20
3981.1Hz	93.1	93.2	93.3	-1.0	1.0	0.2	0.20
7943.3Hz	90.9	91.0	91.2	-3.0	1.5	0.3	0.20
12589Hz	87.7	87.8	88.1	-6.0	3.0	0.4	0.20

Frequency weighting Lin (5.5.4)

	Expected [dB SPL]	Measured [dB SPL]	Corr. Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
1000Hz Ref.	94.0	93.9	93.9	-0.2	0.2	-0.1	0.12
31.623Hz	93.9	94.0	94.4	-1.5	1.5	0.5	0.20
63.096Hz	93.9	94.0	94.3	-1.5	1.5	0.4	0.20
125.89Hz	93.9	93.9	94.1	-1.0	1.0	0.2	0.20
251.19Hz	93.9	93.9	94.2	-1.0	1.0	0.3	0.20
501.19Hz	93.9	93.9	94.1	-1.0	1.0	0.2	0.20
1995.3Hz	93.9	94.0	94.0	-1.0	1.0	0.1	0.20
3981.1Hz	93.9	94.0	94.1	-1.0	1.0	0.2	0.20
7943.3Hz	93.9	94.1	94.3	-3.0	1.5	0.4	0.20
12589Hz	93.9	94.3	94.6	-6.0	3.0	0.7	0.20

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No. 0174

Certificate Number:

C0903169

Time weighting Fast (5.5.5)

Time weighting was tested by comparing the response of a single sinusoidal Burst with the response of a continuous sinusoidal signal at a level 4 dB below the upper limit of the primary indicator range. The test frequency is 2000 Hz.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
Ref. 116 dB	116.0	116.0	-0.2	0.2	0.0	0.20
Burst Meas. 116 dB	115.0	114.9	-1.0	1.0	-0.1	0.20

Time weighting Slow (5.5.5)

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
Ref. 116 dB	116.0	115.9	-0.2	0.2	-0.1	0.20
Burst Meas. 116 dB	111.8	111.8	-1.0	1.0	0.0	0.20

Peak response (5.5.6)

The onset time of the peak detector has been tested by comparing the response to a 100 µs rectangular pulse with the response to a 10 ms reference pulse of the same amplitude and polarity.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
10 ms, Pos Ref.	119.0	119.0	-0.2	0.2	0.0	0.20
100 µs, Pos	119.0	117.2	-2.0	0.0	-1.8	0.20
10 ms, Neg Ref.	119.0	119.0	-0.2	0.2	0.0	0.20
100 µs, Neg	119.0	117.2	-2.0	0.0	-1.8	0.20

R.M.S. accuracy (5.5.7)

The r.m.s. accuracy has been tested on the reference range for a crest factor of 3 by comparing the response to a sequence of tone bursts with that for a continuous sinusoidal signal of 2000Hz at a level at 2 dB below the upper limit of the primary indicator range.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
Ref. 118 dB	118.0	117.9	-0.2	0.2	-0.1	0.20
Burst Meas. 118 dB	117.9	117.9	-0.5	0.5	0.0	0.20

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

CERTIFICATE OF CALIBRATION

UKAS ACCREDITED CALIBRATION LABORATORY No. 0174

Certificate Number:

C0903169

Time weighting I (5.5.8)

Time weighting Impulse has been tested by comparing the response of a single sinusoidal Burst with a duration of 5 ms, and a repetitive Burst with the duration of 5 ms and a repetition frequency of 100 Hz, with the response of a continuous sinusoidal signal at a level at the upper limit of the primary indicator range. The test frequency is 2000 Hz.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]	Coverage Factor [k]
Ref. 120 dB	120.0	120.0	-0.2	0.2	0.0	0.20	2.00
Sing. Burst Meas. 120 dB	111.2	111.3	-2.0	2.0	0.1	0.60	2.17
Cont. Burst Meas. 120 dB	117.3	117.2	-1.0	1.0	-0.1	0.20	2.00

Time averaging (5.5.9)

The time averaging has been tested on the reference range by comparing the response to a continuous sinusoidal signal of 4000 Hz, with that for a sequence of tone bursts having the same equivalent level.

	Expected [dB Leq]	Measured [dB Leq]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]	Coverage Factor [k]
Ref. Cont.	100.0	99.9	-0.2	0.2	-0.1	0.20	2.00
Leq 1/1000	99.9	99.4	-1.0	1.0	-0.5	0.60	2.17
Ref. Cont.	90.0	89.9	-0.2	0.2	-0.1	0.20	2.00
Leq 1/10000	89.9	89.5	-1.0	1.0	-0.4	0.60	2.17

Pulse range and sound exposure level (5.5.10 and 5.5.11)

The Pulse range has been tested by comparing the response to a single sinusoidal burst with the theoretical value of the equivalent continuous level of the test signal. The Sound Exposure Level where available has been determined using the same test signals.

	Expected [dB Leq]	Measured [dB Leq]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
Ref. Cont., 108	108.0	107.9	-0.2	0.2	-0.1	0.20
Leq 10mS, 108	77.9	77.8	-1.7	1.7	-0.1	0.20
SEL 10mS, 108	87.9	87.8	-1.7	1.7	-0.1	0.20
Ref. Cont., 125	125.0	124.8	-0.2	0.2	-0.2	0.20
Leq 10mS, 125	94.8	94.8	-1.7	1.7	0.0	0.20
SEL 10mS, 125	104.8	104.8	-1.7	1.7	0.0	0.20

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

CERTIFICATE OF CALIBRATION

Certificate Number:

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UKAS ACCREDITED CALIBRATION LABORATORY No. 0174

Overload indication, Non-integrating (5.5.12)

Non-integrating mode. The overload indicator has been tested using a sequence of tone bursts as specified in BS7580 clause 5.5.7. The level of the tone bursts was increased until an overload indication occurred. The level was then reduced by 1dB so that no indication occurred. The level was further reduced by 3dB and the meter indication recorded.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]
Non-integrating	121.0	121.0	-0.4	0.4	0.0	0.20

Overload indication, Integrating (5.5.12)

Integrating Mode. The overload indicator has been tested using single sinusoidal bursts with duration of 1 ms at a frequency of 4000 Hz. The level of the burst was increased until the meter just indicated a permanent overload. The signal was then reduced by 1dB and the meter indication recorded. With a continuous signal of the same amplitude applied the meter indication was recorded. The expected level is the continuous level less 40 dB.

	Continuous Level [dB Leq]	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	Uncertainty [dB]	Coverage Factor [k]
Integrating	130.1	90.1	89.6	-2.2	2.2	-0.5	0.50	2.17

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

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Acoustic calibration at 1000 Hz (5.6.1)

The complete instrument has been calibrated at reference conditions, 1000 Hz at 94 dB. A correction in accordance with manufacturers data was made for the difference between the free field and pressure response of the microphone supplied to determine the adjustment level. If a correction for the effect of body influence is required so that the meter reads correctly, this has also been included in the determination.

	Coupler Pressure Lc [dB SPL]	Mic. Correction C4226 [dB]	Body Influence bi [dB]	Adjustment Level [dB SPL]
Ref. Conditions	93.93	0.20	0.00	93.7

Acoustic test at 125 and 8000 Hz (5.6.2)

The complete instrument has been tested using continuous acoustical signals of 125 Hz and 8000 Hz relative to the reference reading at 1000Hz. Corrections in accordance with manufacturers data were made for the difference between the free field and pressure response of the microphone supplied to determine the expected reading. Manufacturers data for body influence has been used in calculating the corrected measured readings representing use within free field conditions.

	Coupler Pressure Lc	Mic. Correction C4226	Body Influence bi	Measured	Corrected Measured	Free Field Level	Response (Rel Ref)	Expected	Accept - Limit	Accept + Limit	Deviation	Uncertaint
	[dB SPL]	[dB]	[dB]	[dB SPL]	[dB SPL]	[dB SPL]	[dB]	[dB SPL]	[dB]	[dB]	[dB]	[dB]
1000Hz Ref.	93.93	0.20	0.00	93.8	93.80	94.0	0.0	0.0	-0.2	0.2	0.0	0.20
125.89Hz	93.94	0.00	0.10	78.0	77.99	78.1	-15.9	-16.1	-1.0	1.0	0.2	0.20
7943.3Hz	93.56	4.00	0.00	88.9	89.27	93.3	-0.7	-1.1	-3.0	1.5	0.4	0.40

Response to sound calibrator (5.6.3)

The response to the associated Sound Calibrator has been recorded.

	Measured [dB SPL]	Uncertainty [dB]
Ref.	93.9	0.10

------------------------------ **End** ------------------------------

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor k>=2.

Appendix 6

Compliance weightings used to establish venues compliance with the Noise Regulations, 2007 and HSA "Noise of Music" guidance document

Table A: Compliance assessment: Noise survey

Items:	Weighting
Has a formal noise assessment been carried out?	10
Has the assessment been produced by a competent person?	5
Does the noise assessment reflect current conditions within the venue?	10
Does the assessment identify those employees exposed above the lower and upper exposure action values? Is the level of exposure indicated?	10
Does the assessment contain an action plan?	10

Table B: Compliance assessment: Noise control measures (based on the HSA "Noise of Music" guidance document

Items:	Weighting
Was the amplified music played at maximum power?	10
Was high quality equipment used which works without distortion? Was the sound equipment routinely maintained?	15
Were the sound levels monitored during venue operation using a device that highlighted if the pre-set noise levels were exceeded?	10
Were loudspeakers suspended speakers to increase distance of loudspeakers to employees?	10
Were loudspeakers faced away from where employees were working?	10
If loudspeakers were directed at employees could they be individually controlled?	10
Were employees rotated from the noisy areas to quieter areas during their work shift?	10

Table C: Compliance assessment: Noise information, instruction and training

Items:	Weighting
Have employees been provided with information, instruction and training on noise? Is there evidence for this?	10
Is the information, instruction and training appropriate to the levels of exposure?	10
Is the training programme well documented including logs of attendance?	5

Table D: Compliance assessment: Audiometry

Items:	Weighting
Is audiometry provided for employees exposed to noise?	5
Is the implementation of audiometry adequate?	5
Are employees appropriately informed of results?	5
Is the information from audiometric testing used by the employer to assess the overall effectiveness of risk control measures?	5

Table E: Compliance assessment: Personal hearing protection

Items:	Weighting
Is Hearing Protection Zone signage identified and delineated?	10
Is hearing protection made available to employees exposed to an $L_{EX,8h}$ between 80 dBA and 85 dBA?	20
Is hearing protection worn by all employees exposed to an $L_{EX,8h}$ above 85 dBA?	20
Do employees have ready access to hearing protection in the venue?	10
Is suitable hearing protection supplied?	5
Are employees given a choice of hearing protectors?	5
Is specific training on the full and proper use of hearing protection provided to employees?	10
Is there monitoring of the mandatory usage of hearing protection?	10
Are all employees observed to be wearing hearing protection?	10

Table F: Compliance assessment: Management

Items:	Weighting
Is there a clearly identified individual responsible for compliance with the Noise Regulations, 2007?	20
Does the identified individual have access to appropriate training, resources and advice in order to carry out the role?	10
Is a system in place to ensure that hearing protection is maintained in an efficient state and replaced as necessary?	10
Are noise control measures subject to review to ensure that exposures are reduced to the lowest level reasonably practicable?	5

Appendix 7

Enforcement officers' questionnaire made available online at Survey Monkey

Noise enforcement questionnaire for Environmental Health Officers in Northern Ireland.

Title of research: Occupational noise exposure in amplified music venues in Leinster: an exploratory risk analysis

Researcher: The research is being carried out by Aoife Kelly, in the School of Food Science and Environmental Health, Cathal Brugha Street, Dublin Institute of Technology.

Aim of study: During the research project 20 nightclub venues in the Leinster region have been inspected to measure the occupational noise exposure of employees and the suitability of noise control measures in place. Twenty manager interviews, 80 employee questionnaires and 5 focus groups have been conducted to ascertain the nightclub sectors opinions of the Noise Regulations. The final piece of the jigsaw is obtaining the enforcement officers opinion on the Control of Noise at Work Regulations (Northern Ireland) 2006 and the challenges enforcing the legislation in the nightclub sector.

You are invited to participate in this PhD research project. This study will form an important part of a PhD research thesis. Please read the information below before deciding whether or not to participate.

The data generated as a result of the noise enforcement questionnaire shall be treated confidentially. Information collected about you will be kept private. In future published documents, such as journals, all potentially identifying information will be removed; we are committed to protecting your identity.

There will be no penalty if you decide not to complete the noise enforcement questionnaire. You are free to withdraw at any time. Your choice will not affect your relationship with the researcher or the Dublin Institute of Technology institution.

Demographics:

Q1. Please answer the following demographic questions by ticking the appropriate response:

	Yes	**No**	**Don’t know**
Do you work for a local authority/local government?			
Do you have more than 5 years experience working in noise enforcement?			
Have you hold any formal qualifications specifically in the area of noise measurement e.g. certificate, diploma, degree?			
Did you attend the "Sound Advice" noise training session delivered by the Chief Environmental Health Officers Group NI (CEHOG) in Craigavon on the 23rd November 2010?			

Noise enforcement in nightclub venues:

Since April 2008, the revisions to the requirements of the Control of Noise at Work Regulations (Northern Ireland) 2006 have been applicable to the nightclub sector.

The following questionnaire is based on your experience enforcing the Control of Noise at Work Regulations (Northern Ireland) 2006 in the entertainment industry with specific reference to nightclubs and venues that hire a DJ to play pre-recorded amplified music.

Q2. How do you currently measure compliance to the Control of Noise at Work Regulations (Northern Ireland) 2006 in nightclubs/venues? (Please tick as many options that apply)

Assess the risk assessment document for daily noise exposure, exposure action values, exposure limit values and control measures.	
Conduct a desk based document audit including examination of training and audiometric files.	
Take noise measurements in the venue during operating hours using a sound level meter or dosemeter.	
Inspect the implementation of control measures while in the venue.	
Review of suitability of hearing protection provided.	
Determine if there is suitable Hearing Protection Zone signage in the venue.	
Talk to management to establish employee work patterns.	
Talk to staff members about their hearing protection usage.	
Examine case file for type of venue and operating hours/days.	
Complaints review	

Q3. If you have ever served an improvement notice on a nightclub/venue for non-compliance to the Control of Noise at Work Regulations (Northern Ireland) 2006, did the improvement notice bring improvement in any of the following ways, where applicable? (Please tick as many options that apply)

Not applicable.	
Noise risk assessment completed.	
Reduction in noise levels.	
Introduction of organisation or technical control measures e.g. staff rotation, facing speakers away from bar areas or installing a sound limiter device.	
Introduction of suitable hearing protection.	
Designation of a Hearing Protection Zone with suitable signage.	
Noise training delivered to employees.	
Audiometric testing carried out on employees.	
Other (please specify)	

Q4. Please provide details of any initiatives your office/department have participated in to encourage noise compliance from the nightclub sector. Include details of the initiatives taken and their level of success. Example: Requested a formal noise risk assessment from each venue but it was not successful due to limited responses from the venue managers.

Q5. In the nightclub/venues in your enforcement area how would you rate the following? (Please tick one option per question)

	Not met	**Partially met**	**Fully or almost fully met**
Management's knowledge of the requirements of the Control of Noise at Work Regulations (Northern Ireland) 2006:			
A formal noise risk assessment supplied by venue management:			
Adherence to the control measures outlined in the risk assessment:			
Hearing protection worn by employees where needed:			
Designation of a Hearing Protection Zone with suitable signage where needed:			
Audiometric hearing tests provided to venue employees where needed:			
Noise training provided to venue employees where needed:			

Q6. As an enforcement officer, do you face any of the following challenges related to the enforcement of the legal requirements of the Control of Noise at Work Regulations (Northern Ireland) 2006 in the nightclub/venue sector? (Please tick as many options that apply)

Limited number of enforcement staff in office/department.	
Noise enforcement is not a priority.	
Budgetary constraints.	
Lack of noise equipment e.g. sound level meters or dosimeters.	
Lack of guidance for enforcers on assessing suitability of noise risk assessments.	
Inexperienced at measuring noise levels.	
Poor knowledge of the calculation of daily noise exposure for employees.	
Unsure of suitable control measures for the management of noise in the venues.	
Unable to select suitable hearing protection based on the noise levels.	
Out of office hours work.	
Aggression from venue management.	
Difficulty contacting venue management.	
Personal safety while in venue during operating hours.	
Concern over my own noise exposure while inspecting loud venues.	
Other (please specify)	

Q7. Do you think the following requirements of the Control of Noise at Work Regulations (Northern Ireland) 2006 are suitable for the nightclub/venue sector? (Please tick one option per question)

	Yes	No	Don't know
Provision of a noise risk assessment where needed:			
Implementation of suitable organisational and technical control measures e.g. sound limiter devices or staff rotation where needed:			
Employees to wear suitable hearing protection where needed:			
Designation of Hearing Protection Zones with suitable signage where needed:			
Providing audiometric testing to employees where needed:			
Providing noise training to employees where needed:			

Q8. How do you think enforcement of the Control of Noise at Work Regulations (Northern Ireland) 2006 could be improved? (Please tick as many options that apply)

More information on the requirements of the legislation provided to venue managers.	
Increase guidance from enforcers on suitable noise control measures.	
Additional noise monitoring by enforcers.	
Increase demand for suitable risk assessments by enforcers.	
Develop noise awareness training aimed at venue managers.	
More enforcement notices issued to venues.	
More follow ups on enforcement notices.	
Increased serving of improvement notices on venues.	
Objections to late night operating licenses being renewed based on non-compliance to the Control of Noise at Work Regulations (Northern Ireland) 2006.	
Unannounced noise spot checks carried out by enforcers.	
Comment on suitable design features for new nightclub/venue fit-outs.	
Other (please specify)	

9. How do you think nightclub venues could improve their compliance to the Control of Noise at Work Regulations (Northern Ireland) 2006? (Please choose as many options as applicable)

Appoint a noise consultant annually to review the noise control documents and risk assessment.	
Attend noise awareness training designed for management.	
Hire an external trainer to raise noise awareness in employees.	
Monitor noise levels in the venue using a sound level meter.	
Be open to developing a research relationship with hearing protection companies to develop a suitable hearing protector for venue employees.	
Engage with EHO's openly during inspections.	

10. Do you have any additional comments?

Appendix 8

Focus group discussion guide.

The green questions were identified as the most important questions to pose to the focus groups.

Focus Group Discussion Guide

1. Individual risk perception – Employee attitudes to noise and knowledge of its effects

1. Which one would you consider to the loudest sound, a nightclub, a rock concert, listening to your MP3 player at maximum volume or all three?
2. What makes you think that?
3. From your own personal experience when you hear the word noise what comes to mind?
4. On a scale of 1 – 10 how loud do you think the nightclub is? One being the quietest and 10 being the loudest. What reasons do you have for that?
5. What is your opinion on the noise level in this nightclub?
6. How does working in a loud environment make you feel?
7. What sounds do you need to hear at work?
8. Do you think loud noise can have an effect on your health?
9. Do you think having a hearing test would be beneficial to you?

2. Barriers to wearing hearing protection – Employees opinions on hearing protection.

10. In your opinion what advantages and disadvantages are there are to wearing hearing protection in your workplace?
11. Has anyone ever experienced a problem with hearing protection?
12. Were you ever asked to wear some type of hearing protector at work? If so, do you usually wear the hearing protection? Why/why not?
13. Which one would you choose to wear? Why did you/did not choose that one?
14. If you could design the perfect hearing protector what would it be like?
15. If you were asked to wear hearing protection next week, how would you feel?

3. Safety Climate in Nightclubs

16. My nightclub managers are very concerned about noise in this nightclub.
17. I don't have any control over the noise levels in the nightclub.
18. There is a lack of volume control in this nightclub.
19. Management think that the louder the music, the better the nightclub.
20. Can you finish this sentence, I believe management think that noise management is……..

4. Noise Management –Employee opinions on how to control noise in the nightclub

21. Imagine you are the manager of the nightclub and you have a blank cheque. What one thing about noise in your workplace would you change and what is the main reason that one thing needs changing? Prompt if no ideas generated what they think about sound limiters, staff rotation, hearing protection, reducing the volume.
22. Can you remember back to a time when management spoke to you about noise in the nightclub? Can you tell us about it? If no examples, how any health and safety topic was discussed?
23. If you told management that you found the nightclub noise levels too high what do you think they would say?
24. What are the challenges that a nightclub faces when trying to become compliant with noise legislation?
25. Is there anything that you think the HSA could do?

5. Noise awareness training - Employee opinions on necessary training content and delivery

26. Can you think back to any training you have received in the workplace about noise? Does anyone have an example? Where was this training? Who delivered it?

"I am looking to develop noise awareness training for the nightclub sector. Would you be able to give me any advice?"

27. What would you like to know about noise? Would you like to know how to protect your hearing outside of work too?
28. Who would you like to give the training, a manager, an outside person like me?
29. How long do you think the training should be?
30. How would you like to receive the training?
31. When do you think is the best time to carry out the training?

Appendix 9

Focus group consent form

Voluntary Nightclub Employee Consent Form

Research Title: Occupational noise exposure in amplified music venues in Leinster: an exploratory risk analysis

Researcher: Aoife Kelly, School of Food Science and Environmental Health, Dublin Institute of Technology. **Email:** [redacted]

You are invited to participate in this research project which is being carried out by Aoife Kelly. Your participation is voluntary. This study will form an important part of a PhD research thesis.

Purpose of the Focus Groups

The focus group is designed to investigate your opinions and experiences about the following topics:

- Noise in your workplace.
- Hearing protection.
- Nightclub management of noise.
- Noise awareness training.

Time commitment

Your participation in this focus group will last approximately two hours.

Risks and Discomforts

We do not anticipate any discomfort to you from being in this study. We will emphasize to all participants the importance of confidentiality.

In the focus groups, questions are directed to the group, not to individuals. You have the right to: (a) not answer a question, (b) terminate the interview, or (c) withdraw from the study at any time in the process.

Confidentiality

The data generated as a result of the focus group shall be treated confidentially. Information collected about you will be kept private. In future published documents, such as journals, all potentially identifying information e.g. participants and the nightclub's names will be removed; we are committed to protecting your identity.

Refusal or Withdrawal without Penalty

Your taking part in this focus group is your choice. There will be no penalty if you decide not to be in the focus group. You are free to withdraw from this focus group at any time. Your choice to leave the focus group will not affect your relationship with the researcher or the Dublin Institute of Technology institution.

Legal Rights

You are not waiving any of your legal rights by signing this informed consent document.

Signature

I have read, or had read to me, this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction. I freely and voluntarily agree to be part of this focus group, though without prejudice to my legal and ethical rights. I understand I may withdraw from the focus group at any time. I understand I will receive a copy of this consent form.

Signature of participant

Participant Signature: ______________________________ Date____________

Name in Block Letters: ____

Signature of researcher

I believe the participant is giving informed consent to participate in this study

Signature of Researcher: _____________________________ Date____________

Appendix 10

Focus group demographics form

Focus Group Demographic Questions

To aid in the analysis of the data, we would appreciate you sharing a little information about yourself. Unless otherwise indicated, please tick the item which best reflects your situation.

1. **Gender:** Male ☐ Female ☐

2. **Age:** _________ Prefer not to say ☐

3. **Which one of the following best describes your job title in the nightclub?**

   ☐ Bar Staff ☐ Glass Collector

   ☐ Security ☐ Other (Please describe) ______________________

4. **How many years in total have you worked in the nightclub industry?** _______ years

5. **How long have you worked in this specific nightclub?** ___________ years

6. **How many hours do you currently work per week in the nightclub?** _________ hours

Thank you for your participation in this study

Appendix 11

Training intervention consent form

Voluntary Nightclub Employee Consent Form

Research Title: Occupational noise exposure in amplified music venues in Leinster: an exploratory risk analysis

Researcher: Aoife Kelly, School of Food Science and Environmental Health, Dublin Institute of Technology, 31 Marlborough Street, Dublin 1.

You are invited to participate in this PhD research project which is being carried out by Aoife Kelly. Your participation is voluntary. Please read the information below before deciding to participate.

Introduction

In the recent past there was a change in the noise levels employees in all workplaces could be exposed to. This change was in every industry, including nightclubs. It was recognised that this could be a challenge for the entertainment sector. In other industries, the noise may be engineered out. In the nightclub industry, the music is the desired effect, and so the challenge lies in protecting the employees while still delivering the experience the audience expects.

Purpose of the Training Intervention Questionnaire

Currently there is no defined noise awareness training course available for the nightclub industry. During the focus groups I asked for recommendations on how to tailor-make the noise awareness training programme for the nightclub sector. This training has been designed and delivered in a number of nightclubs. In order to measure the effectiveness of the training it is essential to measure how employee's knowledge and attitudes to noise have changed.

What you will be asked to do in the study:

In order to ensure any change recorded is due to the training, it is necessary to ask a group of employees who have not been trained to complete the same questionnaire as those who were trained. This study will involve your participation in a control group.

You will be asked to do the following:

- Complete a questionnaire twice within 2 hours, taking approximately 20 minutes.
- Complete a further questionnaire in a 6-8 weeks time, taking approximately 15 minutes.

Participating in the baseline data collection today does not obligate you to participate in the follow up questionnaire in a few weeks time. At that time you can decide whether or not you want to participate in the follow up questionnaire. We do not anticipate any discomfort to you from being in this study. We will emphasize to all participants the importance of confidentiality.

Confidentiality

The best way to measure the training intervention is to have you complete a questionnaire before and after the training. For this reason the questionnaire is not anonymous but it is confidential and names are only used only for identifying purposes to match up survey results. This means that you will not be identified by name in the research but we will be able to match up your pre and post questionnaire results.

The data generated shall be treated confidentially. Information collected about you will be kept private. In future published documents, such as journals, all potentially identifying information e.g. participants and the nightclub's names will be removed; I am committed to protecting your identity. Confidentiality will be maintained by coding data and identifying participants as Male 1 or Female 1. The nightclub itself is identified as Nightclub X or Y so you or the venue will not be identifiable. The managers in the nightclub are not involved with the analysis.

Refusal or Withdrawal without Penalty

Your taking part in this control group is your choice. There will be no penalty if you decide not to participate. You are free to withdraw at any time. Your choice to withdraw will not affect your relationship with the researcher or the Dublin Institute of Technology institution.

Legal Rights

You are not waiving any of your legal rights by signing this informed consent document. If you are happy to proceed please complete the following two pages and the questionnaire attached to this consent form.

Signature

I have read, or had read to me, this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction. I freely and voluntarily agree to be part of this control group, though without prejudice to my legal and ethical rights. I understand I may withdraw from the intervention at any time. I understand I will receive a copy of this consent form.

Signature of participant

Participant Signature: ______________________________ Date _____________

Name in Block Letters: ____

Signature of researcher

I believe the participant is giving informed consent to participate in this study

Signature of Researcher: ______________________________ Date ____________

Appendix 12

The pre-training questionnaire that was separated into three sections:

Demographics, knowledge of legislation and attitude to aspects of HBM constructs

Demographics

To aid in the analysis of the data, we would appreciate you sharing a little information about yourself. Unless otherwise indicated, please tick the item which best reflects your situation.

1. **Name in block letters:** ____

2. **Gender:** Male ☐ Female ☐

3. **Age:** _________ Prefer not to say ☐

4. **Nationality:** ____

5. **Level of education:**
   - ☐ Primary School
   - ☐ Leaving Certificate
   - ☐ Junior Certificate
   - ☐ College/3rd Level

6. **Which one of the following best describes your job title in the nightclub?**
   - ☐ Bar Staff
   - ☐ Glass Collector
   - ☐ Security
   - ☐ Other (Please describe) ______________________

7. **How many years have you worked in the nightclub industry?** _______ years

8. **How long have you worked in this specific nightclub?** ___________ years

9. **How many hours do you currently work per week in the nightclub?**
   _______ hours

10. **How often do you currently wear hearing protection in your workplace?**
    - ☐ Never
    - ☐ Between 51-90% of my work shift
    - ☐ Less than 10% of my work shift
    - ☐ More than 90% of my work shift
    - ☐ Between 10-50% of my work shift

Knowledge of Noise in the Workplace

Please read each question and answer to the best of your ability.

1. **In what year was the revised occupational noise legislation introduced into nightclubs? ____**

2. **Sounds measuring over _____ decibels can be harmful to your hearing.**

   ☐ 75 decibels ☐ 100 decibels ☐ 1000 decibels

3. **What does NIHL stand for? ______________________________________**

4. **Loud music is not as harmful to your hearing as machinery noise at the same decibel level.**

   ☐ True ☐ False

5. **Hearing loss caused by loud sounds is something people ______may have.**

   ☐ Aged over 60 ☐ Aged over 50

   ☐ Aged over 40 ☐ Of any age

6. **Give three examples of things that can make sounds louder than 85 decibels:**

   ____

   ____

   ____

7. **Wearing suitable earplugs can save your hearing from damage to loud noise.**

   ☐ True ☐ False

8. **When should you wear hearing protectors in work?**

   ____

9. **Give two examples of the measures management have taken to control noise in the nightclub.**

____

____

10. **Employers must make hearing protection available when the noise level exceeds 80 decibels.**

☐ True ☐ False

Adapted Health Belief Model Attitudes

Please read each item and tick the box that best describes your opinion about the statement. Remember, there is no right or wrong answers! In this section we are interested in your opinions.

Note: * signifies that for data entry the Likert scale was reverse scored

Perceived susceptibility to hearing loss	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
I believe exposure to loud music can hurt my hearing.					
My hearing will be affected by noise if I don't wear my hearing protection.					
Perceived severity of the consequences of hearing loss	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
* It would not bother me if I lost part of my hearing because of the loud music I work around.					
It would be harder for me to understand what people say if I lost some of my hearing.					

Perceived benefits of preventive action	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
I can't protect my hearing unless I wear hearing protectors around loud music.					
Preventing hearing loss is very important to me.					
Perceived barriers to preventive action	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
* Earplugs can be comfortable to wear if they fit right.					
It is hard to hear fire alarms if I am wearing hearing protection in the nightclub.					
* Wearing hearing protectors does not stop me from hearing customers' orders.					
Wearing hearing protection makes it very hard to talk to people in work.					
Even when it's not noisy, sometimes it's hard for me to hear when people are talking to me.					
Hearing protectors are not readily available for me to use where I work.					
Hearing protectors are too expensive for the nightclub to buy.					

Behavioural intentions:	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
* I usually don't wear hearing protectors while I am working around loud music at work.					
* Even if I had one with me at work, I probably wouldn't wear a hearing protector every time I was around noise that was loud enough to hurt my hearing.					
Interpersonal influences:	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
My co-workers usually wear hearing protectors when they need to work in the nightclub.					
My co-workers remind me to use hearing protection at work.					
Self-efficacy:	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
I believe I know how to fit and wear hearing protectors.					
If co-workers asked me, I could show them how to fit and wear hearing protectors the right way.					
I know how to wear hearing protection correctly.					

Appendix 13

Anonymous noise training evaluation form

1. **Gender:** ☐ Male ☐ Female

2. **Do you feel that the information provided has increased your awareness of the importance of wearing hearing protection?**

   ☐ Yes ☐ No ☐ Don't Know

3. **How useful did you find the following during the training:** (please tick one only from each question)

		Very useful	Useful	No opinion	Not very useful	No use at all
A	Examples of hearing loss given in PowerPoint.					
B	General opportunity for discussing issues.					
C	The opportunity to try out different types of hearing protection.					

4. **How useful did you find the information about noise at work:** (please tick one only from each question)

		Very useful	Useful	No opinion	Not very useful	No use at all
A	The legal duties of employers and employees.					
B	How hearing can be damaged.					
C	Levels of noise that might cause hearing loss.					
D	Where and when hearing protection should be worn.					
E	How to wear hearing protection properly.					

5. **What was the most useful part of the training, and why?**

   ____

   ____

6. **What was the least useful part of the training, and why?**

____

____

____

____

7. **Was there any part of the training that you felt was covered too fast or too slow? If so please detail.**

____

____

____

____

8. **Are there anymore you feel could have been included in the training? If so please detail.**

____

____

____

____

9. **What was the most useful thing you learned in this course?**

____

____

____

____

10. **How well did the trainer keep the training alive and interesting?**

Excellent	**Good**	**Fair**	**Poor**

11. **What is your overall rating of the trainer?**

Excellent	**Good**	**Fair**	**Poor**

Appendix 14

The complete 26-item questionnaire related to safety culture

Reverse scored statements highlighted with an astrix

Safety Culture Questionnaire

Personal motivation	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
It would help me to work more safely if my supervisor praised me on safe behaviour.					
It would help me to work more safely if safety procedures were more realistic.					
It would help me to work more safely if management listened to my recommendations.					
It would help me to work more safely if we were given safety training more often.					
It would help me to work more safely if management carried out more workplace safety checks.					
It would help me to work more safely if my workmates supported safe behaviour.					
Positive safety practice	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
Our management supplies enough safety equipment					
There is adequate safety training in my workplace					
Management in my workplace is as concerned with people's safety as it is with profits					

Everybody works safely in my workplace					
All the safety rules and procedures in my workplace really work.					
Risk justification	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
When I have worked unsafely it has been because I didn't know what I was doing wrong at the time.					
When I have worked unsafely it has been because the right equipment was not provided or wasn't working.					
Fatalism	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
Safety works until we are busy then other things take priority.					
If I worried about safety all the time I would not get my job done.					
Accidents will happen no matter what I do.					
I can't do anything to improve safety in my workplace.					
Optimism	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*

It is not likely that I will have an accident because I am a careful person.					
People who work to safety procedure will always be safe					
People who do not take the necessary precautions are responsible for what happens to them. *(reverse scored)					
Safety climate	*Strongly Agree*	*Agree*	*Neither Agree Nor Disagree*	*Disagree*	*Strongly Disagree*
My managers set a good example for me when it comes to wearing hearing protection. * (reverse scored)					
I do not think preventing hearing loss from noise is very important to my managers. * (reverse scored)					
My manager frequently checks to see if I am obeying the safety rules.					
My manager does remind me to work safely if I am not doing so					
My manager says a "good word" to me if I pay extra attention to safety.					
My manager would never say I have to wear my hearing protectors, even I they are not comfortable. * (reverse scored)					