Auditory Effects of Noise Exposure at the Place of Work

by Sreeraj K

ARF PROJECT PROPOSAL

Part A

1.0	**Title of the Project**	**Auditory Effects of Noise Exposure at the Place of Work**
	Area of Research	Others: Environmental Audiology
1.1	**Principal Investigators**	Mr. Sreeraj Konadath Lecturer in Audiology AIISH, Mysuru sreerajkonadath@aiishmysore.in
1.2	**Collaborating Institution/ Organization**	NIL
1.3	**Total Grants Required**	`5,30,000/-
1.4	**Duration of the Project**	12 months

2.0 Project Summary

The current project aims to measure the levels of noise at different work set up pertaining to work environment where the following professionals work: traffic police, auto drivers, bus drivers, street vendors and welders and to assess the auditory functions in these individuals. Also, the study aims to measure the effect of noise at their work place, measured through noise annoyance questionnaire. Noise levels in the workplace will be measured using calibrated SLM. Totally 20 recordings in each of the work setting would be carried out and averaged to find out the average level of noise exposure in work place across different professions.. Further, detailed audiological evaluations will be carried out to study the impact of noise exposure on auditory capabilities of these individuals. The results obtained in the current study will be analysed to see the effects of noise at workplace on auditory ability of these individuals as a function of their line of profession and duration of exposure to noise in their respective profession. Results of the current study would help us to understand the amount of noise, individuals at different professions are exposed at their workplace and which profession is greater associated with the adverse effects of noise exposure. The study would also enlighten the employers/individuals about adopting hearing conservation program and to take up necessary actions to control adverse effect of noise exposure at their workplace.

3.0 Introduction

3.1 Definition of the problem

Due to advancement in urbanization there is a steady increase in environmental noise levels and noise has become a necessary part of urban soundscape. Exposure to noise above the permissible limits may have auditory and non-auditory effects. Non-auditory effects encompass anxiety, restlessness, stress and sleep disturbances (Cohen & Weinstein, 1981). With respect to the auditory system, noise exposure causes temporary threshold shift (TTS) and permanent threshold shift (PTS).

Although the relation among exposure to high level of occupational noise and its adverse effects has been known for decades, occupational noise induced hearing loss still exists as a global health problem (Lao et al, 2013). During the last few decades, most of the research on occupational NIHL have been focused mainly on the workers in traditional industries. With the recent shift in the economy from a manufacturing base to a service base, there has been growing concern that NIHL affects not only the traditional noisy trades, but also many employees in the service sector (such as Drivers, Vendors, cafeteria employees, etc.,). Although certain studies have measured the noise levels in work places across different job set, audiological evaluation of individuals exposed to noise is confined to threshold estimation and administration of questionnaires in such studies. There is dearth of information on complete audiological profiling on effect of occupational noise on the auditory system in individuals working across different work environment.

3.2 Objectives

- To measure the levels of noise at different work set up pertaining to work environment, where the following professionals work:
  - traffic police,
  - auto drivers,
  - bus drivers,
  - street vendors and
  - welders
- To assess the auditory functions in these individuals and
- To study the annoyance created by noise at the place of work using a questionnaire.

3.3 Review of status of research and development in the subject

Exposure to excessive noise has been identified as one of the major cause of hearing disorders. It has been estimated that worldwide as many as 500 million individuals might be at risk of developing noise-induced hearing loss (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). Exposure to high levels of noise is associated with damage to the sensory hair cells of the inner ear and could lead to development of permanent hearing threshold shift, as well as poor speech in noise intelligibility (Mikulski & Radosz, 2011). There is also evidence that noise exposure often leads to tinnitus which might be due to alterations in the central auditory function (Nelson et al., 2005). In the adult population it may significantly influence quality of life, and bring about a major limitation in relation to hearing-critical jobs and thereby, decreasing the potential worker's chance of employment. Thus, NIHL not only affects health, but is also a major social problem.

There are several standards and guidelines formulated to monitor the exposure to noise levels at work place. OSHA (1983) recommends an exposure limit of 85 dB (A) for 16 hours per day, and a 5-dB time-intensity trade off. For every 5 dB increment in noise level, the permissible exposure time is reduced by half and for every 5 dB decrement in noise level, the permissible exposure time is doubled. Similarly, NIOSH (1998) permits an exposure of 85 dB (A) for 8 hours per day, and uses a 3 dB time-intensity trade off. Although, the limit to noise exposure has been called for by setting up certain standards, the levels of noise to which workers are exposed who are working in different set up remains alarmingly high, putting them at the risk of development of noise induced hearing loss.

Ingle, Pachpande, Wagh and Attarde (2004), estimated typical sound levels prevailing at the work place environment of traffic policemen. Data on self-reported health status was collected by questionnaire and an audiometry used to determine hearing threshold at high and low frequencies. Eighty-four percent of the sample reported hearing loss and defined at least some difficulty in hearing by one or both ears. The prevalence of audiometric hearing impairment defined as a threshold average greater than 25dB (A) hearing level was 80% for binaural low frequency average (250, 500 and 1000Hz), 70% for binaural mid-frequency average (1000, 2000, 3000 and 4000Hz) and 46% for binaural high frequency average (3000, 4000, 6000 and 8000Hz) in the traffic policemen.

Similarly Sliman, Ibrahim and Ahemad (2015), measured exposure of traffic men to noise levels in city of Sudan. It was observed that at all points, the level of noise was higher. Major effects of noise among traffic police officer include annoyance and tinnitus.

Leong and Laortanaku (2003) assessed the noise exposure of road side workers to traffic noise levels in the city of Bangkok. Four different categories of occupational people, i.e., drivers, street vendors, traffic officers and dwellers were selected and were further classified into age groups (16–25, 26–

35, 36–45 and 46–55 years old) to monitor the traffic noise induced hearing loss throughout their everyday lives. During the monitoring period, noise levels were found to be 72.8–83.0 dBA during day time and 59.5–74.5 dBA during night time. According to the audiometric investigation, it was revealed that hearing capacity of the daily noise exposure groups living in the urban sites were noticeably poorer than those who were living in suburban site. Among the occupational population who were living in the urban monitoring sites, the driver groups were found to have the highest risk of traffic noise induced hearing loss.

Siddique et al (2015), studied effect of road traffic noise on human beings in busy places of Karachi, working at these places. A sample of 125 cases were randomly selected who had noise exposure of 90 dB or above of their surroundings for more than 6 months. Noise levels at different busy traffic intersections of Karachi were taken by a sound level meter branded "Standard Sound Level Meter ST-85A". Pure Tone Audiogram on a screening mode of 500Hz, 1000Hz, 2000Hz, 4000Hz and 8000Hz was obtained in a sound proof room. Varying degree of hearing loss was evaluated in subjects where 17.6% were normal, 33.6% had mild hearing loss, 45.6% had moderate and 3.2% had moderately severe hearing loss. Traffic noise was found to bother 55.2% of subjects.

Pettersson, Burström, Hagberg, Lundström and Nilsson (2012) examined the possible association of combined exposure of noise and hand-arm vibration (HAV) and the risk of noise-induced hearing loss. Workers in a heavy engineering industry were part of a dynamic cohort. The workers were welders/grinders, engineers, supervisors, salesmen, and administrators. Personal noise exposure measurements were done on a sample of the participants (n=15) working as welders/grinders and supervisors. The measured noise exposure levels from the selected grinders and hammers varied between 77 and 109 dB (A) with a mean of 95 and standard deviation 7 dB (A). The background noise exposure levels varied between 75 and 88 dB (A) with a mean of 85 dB (A). All audiograms were performed with screening pure-tone audiometry using a calibrated Entomed SA 202 automatic audiometer in a soundproof booth. The vibration acceleration exposure from hand-held vibrating tools was measured under normal working conditions at all relevant workstations. The results show that working with vibrating machines in an environment with noise exposure increases the risk of hearing loss, supporting an association between exposure to noise and HAV, and noise-induced hearing loss.

Karimi, Nasiri, Kazerooni and Oliaei (2010), investigated the hearing status of 500 truck drivers by pure tone audiometry (AC) in one of the cities in Fars province, Iran. Hearing threshold levels of the subjects were measured in frequencies of 500Hz-8000Hz. The effect of age as a confounding factor was considered using ISO equation and subtracted from whole hearing threshold. The threshold of 25 dB HL and above was considered abnormal. Subjects were categorized into two groups on the basis of working experience and the hearing threshold of 25 dB was considered a boundary of normal hearing sense. The results of Pearson Chi-Square test showed that working experience as an independent variable has significant contributing effect on hearing thresholds of truck drivers in frequencies of 500, 1000, 2000 and 4000 Hz (p greater than 0.05). Also, it was shown that currently nine and 12.6 % of truck drivers suffer from impaired hearing sense in left and right respectively (hearing threshold level greater than 25 dB) in mid frequencies (500, 1000, 2000 Hz) and 45% in high frequencies of both ears (4000 and 8000 Hz). The results indicated that hearing damage of professional drivers was expected to occur sooner at 4000 and 8000 Hz than lower frequencies. Finally it was deduced that the occupational conditions of truck drivers may have bilateral, symmetrical harmful effect on hearing threshold sense in all frequencies mainly in frequency of 4000 Hz.

Majumder, Mehtha and Sen (2009), estimated the risk of hearing impairment in Indian professional drivers in Kolkata city. In this study, 90 healthy male subjects were equally sampled in three separate sub-samples of 30 subjects each viz. drivers with less than 10 years of occupational noise exposure, drivers with more than 10 years of occupational noise exposure and office workers as control. The audiometric testing of both ears of the selected subjects was conducted at frequencies of 0.125, 0.25, 0.5, 1, 1.5, 2, 3, 4, 6, 8 and 10 kHz. The hearing threshold levels of office workers at audiometric test frequencies of 0.5, 1, 2 and 3 kHz did not exceed 25 dB (A) to cause hearing handicap. However, it exceeded 25 dB (A) for professional drivers (<10 years of noise exposure and >10 years of noise exposure). The values of estimated average excess risk indicated that hearing damage of professional drivers was expected to occur sooner at 3 and 4 kHz frequencies than losses at lower frequencies. It was concluded that the occupational hazards of professional driving significantly increased hearing threshold levels of drivers as compared to office workers.

Sen, Bhattacharjee, Banerjee and Sarkar (2010), studied the work exposure for drivers of auto rickshaws in Kolkata, India in a running condition to noise. For studying the characteristics of noise dose at different sites, simultaneous measurement of sound-pressure levels (SPL) at different routes in North Kolkata were taken in running condition in winter, summer season. A history of discomfort in running condition, regarding noise pollution, if any, experienced while driving the auto previously was obtained through questionnaire to different auto drivers in different routes of the city. Type 4444, Noise dose meter was used for assessment of noise levels. The A-weighted values of Leq, L_{10}, L_{90}, TWA (Time weighted Average) and TNI (Traffic Noise Index) were determined. It showed significant effect of noise exposure from auto-rickshaws in Kolkata city of India.

3.4 Importance of the proposed project in the context of current status

- Excessive levels of noise has been documented across different work settings. However, studies profiling complete audiological characteristics in such individuals exposed to noise is limited.
- Studies on comparison of levels of noise across different work environment and its effect on auditory system is limited.
- Level of annoyance due to noise at work place and its impact on quality of life needs to be studied.

4.0 Work Plan

4.1 Method

Subjects/Participants

Individuals in the following profession will be included in the study:

- Auto rickshaw drivers
- Bus drivers

- Traffic police
- Street vendors
- Welders

Twenty healthy individuals in the age range of 15-35 years would be selected for each group in the study. Their hearing sensitivity should be within normal limits (audiometric thresholds within 25dB hearing level from 250Hz to 8000Hz). All the individuals shall be involved in their respective profession for at least 8 hours a day with a minimum work experience of 1 year. Individuals in each group will further be categorized based on their work experience (0-5 years, 5-10 years, 10-15 years and >15 years). Participants should report no previous history of hearing related, psychological related or neurological related problems. Measurements obtained in these individuals shall be compared with the data obtained from a control group who are exposed to minimal level of noise at their workplace (set-up like AIISH).

Materials

- Sound level meter (B & K model 2270) with wind shield
- Tripod stand
- SLM Calibration unit (Piston phone)
- A calibrated clinical diagnostic audiometer (two channel Inventis Piano Plus)
- TDH 39 supra aural headphones/ Sennheiser HDA 200 headphones.
- Diagnostic immittance meter (GSI-tympstar).
- In order to assess the integrity of outer hair cells oto-acoustic emissions, Mimosa acoustics DP 2000 will be used.
- The experiment to assess temporal processing will be run using personal computer [Intel^R core (TM) i3-3110M, 4GB RAM, 64 bit operating system] loaded with MATLAB software.
- Questionnaire to assess noise annoyance and quality of life.
- A two-channel auditory evoked potential system (Biologic Navigator pro) will be used to record ABR and LLR.

Procedure

Phase I: Measurement of noise in workplace

Noise measurement will be carried out across each of work environment using a calibrated SLM mounted on a tripod stand with the microphone placed at the ear level within 1 meter diameter of the individual at work. The settings/ measurement loci for noise to be measured shall be according to the Indian standards for noise measurements. All the measurements would be done using the A-weighing network (in fast mode). The The L_{eq} (Level Equivalent), L_{max} and L_{min} would be measured. Measurement would be done at a site for a duration of 10 minutes. Totally 20 recordings in each of the work setting would be carried out and averaged to find out the average level of noise exposure in work place across different professions.

Phase II: Administering questionnaire

Noise at work questionnaire, to assess perceptions of noise in the workplace (Purdy & Williams, 2002) will be administered.

Phase III: Assessing auditory functions

- Pure tone audiometry (Extended high frequency audiometry up to 16 KHz)

Pure tone thresholds will be obtained at different octaves and mid octaves from 250Hz up to 8000 Hz, using a two-channel audiometer (Inventis Piano) calibrated as per ANSI S3.6 (1996). Speech recognition threshold, and speech identification scores will also be obtained. Stimulus will be routed using TDH 39 headphones. Sennheiser HDA 200 headphones shall be used to obtain extended high frequency thresholds (up to 16 kHz). High frequency thresholds shall be obtained at 10 kHz, 12.5 kHz, 14 kHz, and 16 kHz. Bone-conduction thresholds shall be obtained using bone vibrator (Radio ear B-71) up to 4000 Hz. Thresholds shall be obtained using modified Hughson Westlake procedure.

- Immittance evaluation

GSI-Tympstar middle ear analyzer shall be employed to assess middle ear function using tympanometry and reflexometry. The instrument shall be calibrated as per ANSI, S3.39 (R1996). c. 226 Hz probe tone will be swept from +200 to -400 daPa pressure to obtain the tympanogram. Both ipsilateral and contralateral Acoustic reflex thresholds shall be obtained at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz.

- Assessing Outer hair cell functioning

DPOAE shall be recorded in both ears so as to analyze fine structure characteristics (minimum 8 points/ octave). Recordings shall be done using probe tip of appropriate size. f1/f2 ratio shall be kept constant at 1.22 and intensity of the signal shall be at 65dBSPL (L1) and 55 dBSPL (L2) respectively. A MATLAB code shall be employed to carry out the fine structure analysis of the obtained responses.

- Assessing auditory brainstem functioning using ABR

ABR for site of lesion testing will be carried out to assess any retro cochlear pathology associated with noise exposure. Following parameters shall be employed.

Acquisition parameters	***Stimulus parameters***
Analysis time: 15 ms	Type of stimulus: clicks
Amplification: 50,000x	Duration of stimulus: depending on frequency
Filter: 30 Hz to 3000 Hz	Polarity: rarefaction
Sweeps: 1500	Repetition rate: 11.1 and 90.1 Hz
Mode: mon-aural	Intensity: 70 dB nHL

Electrode montage: vertical (Fpz, Cz, M1/M2)
Electrode impedance: <5K Ohms
No. of channels: Two

- Long latency responses (LLR) for identifying lesion at cortical level

LLR will be recorded to identify higher level retrocochlear lesions associated with exposure to noise, if any; using the following parameters.

Acquisition parameters	***Stimulus parameters***
Analysis time: 600 ms	Type of stimulus: tone burst of 500 Hz Blackman window (2-0-2)
Amplification: 50,000x	Duration of stimulus: Rise/fall: 10 ms; Plateau: 50 ms
Filter: 1 Hz to 100 Hz	Polarity: alternating
Sweeps: 300	Repetition rate: 1.1/sec
Mode: mon aural (Hall, 2006)	Intensity: 70 dB nHL
Electrode montage: vertical (Fpz, Cz, M1/M2)	
Electrode impedance: <5K Ohms	
No. of channels: Two	

- Assessing temporal functions

To assess temporal functioning in individuals exposed noise at their workplace, following tests would be administered.

(i) **Gap detection thresholds**: The participant's ability to detect a temporal gap in the centre of 500 ms broadband noise will be measured (Harris, Eckert, Ahlstrom, & Dubno, 2010). The noise with 0.5 ms cosine ramps at the beginning and the end of the gap will be used for the estimation of gap detection threshold. In a three-block alternate forced-choice task, the standard stimulus was always a 500ms broadband noise with no gap whereas the variable stimulus will contain the gap. The participant task would be to identify which stimulus among the three has a gap.

(ii) **Modulation detection threshold**: A 1000 ms Gaussian noise was sinusoidal amplitude modulated at modulation frequencies of 4 Hz, 8 Hz, 16 Hz, 32 Hz, 64 Hz and 128 Hz (Bacon & Viemeister, 1985; Desloge, Reed, Braida, Perez, & Delhorne, 2011; Viemeister, 1979). Noise stimuli with two 10 ms raised cosine ramps at onset and offset will be used. The participants will be instructed to detect the modulation and determine which block has the modulated noise. Modulated and un-modulated stimuli will be equated to total root mean square (rms) power. The depth of the modulated signal will be varied according to the participant's response up to a 79.4% criterion level. Stimuli will be synthesized using custom scripts in MATLAB 7.

- Speech perception in noise

Speech identification scores in presence of noise will be obtained monaurally for both the ears. Phonemically Balanced Kannada Word Test (Yathiraj & Vijayalakshmi, 2005) shall be used to assess speech identification scores in these subjects. Multi talker babble will be used as the competing stimuli and testing will be carried out at 0 dB SNR.

Analysis

A suitable statistical analysis will be performed on the collected data to

- Study the effect of noise at work place on auditory abilities in individuals working at different professions.
- Effect of duration of noise exposure in each category of profession and comparing it with other profession.

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