Abstract

Background

There is sufficient scientific evidence indicating that excessive and prolonged exposure to noise causes noise-induced hearing loss (NIHL), also known as permanent hearing loss and other non-auditory effects such as sleep disturbance, hypertension, and interference with the nervous and cardiovascular systems. The World Health Organization (WHO) estimated that NIHL costs approximately 0.2% to 2% of the gross domestic product (GDP) of the developed nations in terms of compensation and economic burden on society. It also estimated that more than 16% of the NIHL in adults is attributable to occupational noise exposure. Although preventable, NIHL is one of the most widespread irreversible occupational disease worldwide and thus was declared as a serious occupational hazard.

Worldwide, occupational noise exposure is widely regulated and most countries, including South Africa, use 85 dBA as the occupational exposure limit for noise exposure and has adopted the 3-dB exchange rate, with the exception of the US and Brazil, amongst others, which use the 5-dB exchange rate rule. Exchange Rate is the increase in noise level that corresponds to a doubling of the noise level. A few countries around the world such as the US, Japan and India use 90 dBA as a regulated limit for noise exposure. Acute hearing loss can also occur suddenly if a person is exposed to very high impact noise (above 140 dBC) for a short duration such as explosion and gun shots. Research shows that 8-hour average daily noise exposure levels between 75 dBA and 80 dBA are unlikely to cause hearing loss. The International Organization for Standardization (ISO 1999) “Acoustics - Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment” provides damage risk criterion information that enable the prediction of NIHL at various audiometric frequencies and for varying exposure durations. Attempts to limit human exposure to noise are based on damage risk criterion. For example, the National Institute for Occupational Safety and Health (NIOSH) estimates a risk of NIHL after a 40-year working lifetime of 1% at 80 dBA, 8% at 85 dBA, and 25% at 90 dBA. This shows that the 85 dBA limit does not guarantee safety, since 85 dBA is already indication 8% excess risk.

The WHO has indicated that workers employed in sectors such as manufacturing, transportation, construction, mining, utility, agriculture and military have the highest risk of

NIHL. In the Services sector, which include Garden and Landscaping services, the extensive use of powered lawn maintenance machines results in widespread exposure to high levels of noise. The employees employed in the garden and landscaping sector such as groundskeepers, are in charge of maintaining general landscape of public and private areas such as sporting grounds, community parks and learning institutions grounds. Their main tasks involve a variety of outdoor activities such as clearing leaves, mowing lawns, cutting trees, trimming hedges, applying fertilizer, removing dead or unwanted plants and other general garden maintenance work. Noise exposure, which is one of the main health hazards that severely affect the health of these employees during operation of powered lawn maintenance machines such as leaf blowers, riding and push lawnmowers, brush-cutters and chainsaws can be a significant source of workplace noise exposure among groundskeepers.

Although the literature on occupational noise exposure has concentrated on large industrial sectors (mining, construction, manufacturing and transportation), the problem extends to smaller operations such as lawn maintenance. Recent literature suggests that noise generating activities in small-scale operations, such as lawn maintenance, use high noise emitting machinery.

Purpose

The purpose of this study was to evaluate occupational noise exposure levels of groundskeepers who operate different types of powered lawn maintenance machines at three campuses of a public university in Gauteng and estimate their risk of NIHL.

Methods

A quantitative, cross-sectional study design conducted among groundskeepers following a non-probability convenience sampling strategy was used. Personal and area noise exposure levels were evaluated in accordance with the South African National Standard (SANS) Code of Practice 10083:2013. The measurements for personal noise were conducted using a type 2 Casella dBbadges (personal noise dosimeters), which were placed on the groundskeepers' shoulders, close to the ear adjudged as receiving the highest noise levels covering sufficient time representative of daily (task-based) exposure. Area noise measurements were performed using a type 1 Quest integrating sound level meter (SLM), which was mounted on a tripod stand and placed at approximately 1.5 meters above the floor and 1 m from the noise generating machine. In each measurement position, one-minute measurements were completed, and A-weighted equivalent noise levels (LAeq) were recorded. To ensure accuracy of measurements, the noise measuring instruments were calibrated before and after each series of measurements

using a calibrated portable acoustic calibrator as per the manufacturer's instructions. The SLM and personal noise dosimeters (PNDs) were calibrated using a type 1 acoustic calibrator (Model QC-10, Quest Technologies, USA) and type 2 acoustic calibrator (*Casella CEL 110/2, Regent House, Bedford, U.K*) respectively. No significant shift in calibration was detected for any individual measurement. All the noise measuring instruments were externally calibrated by a South African National Accreditation System (SANAS) 17025 accredited laboratory.

A questionnaire constructed by the primary researcher was utilized to record groundskeepers' demographic information, work processes pertaining to tasks performed and noise exposure levels, including certain elements of hearing conservation practices such as information and training, audiometric testing, and use of hearing protective devices (HPDs).

A total of 18 PND measurements and 17 area noise measurements were conducted at three university campuses i.e. Campus A, Campus B and Campus C. The noise measurements were conducted over a period of five (5) days (1-3 September 2021 and 3-4 November 2021).

Data/ readings from the noise monitoring instruments were manually recorded on predesigned field sheets and manually entered onto Microsoft Excel spreadsheet. Thereafter, a statistical analysis using a one-way analysis of variance (ANOVA) was carried out to determine whether a significant difference existed between the mean personal and area noise exposure levels measured at three university campuses. Formulas from the SANS 10083 standard were used to calculate measured noise levels for comparison with the regulated noise rating limit of 85 dBA using Microsoft Excel spreadsheet.

Results

The results of this study showed that majority, 78% (14 out 18), of groundskeepers' personal noise exposure levels (task-based) in the three campuses exceeded the legislated noise rating limit of 85 dBA, thus increasing groundskeepers' risk to NIHL. Groundskeepers in campus A were exposed to the highest eight-hour equivalent continuous A-weighted sound pressure level (LAeq, 8h) with mean noise levels of 91.5 dBA ±4.7, followed by campus B and C with mean noise levels of 89.1 dBA ±4.0 and 86.9 dBA ±2.9 respectively. Peak noise exposure levels (LCpeak) measured as part of personal noise exposure in the three campuses ranged from 115.6 dB to 140.0 dB. These excessive peak noise exposures are attributed to the types of machines used during lawn maintenance activities. The overall statistical difference in the mean personal noise exposure levels (LAeq, 8h) and peak levels (LCpeak) between the three campuses were found to be not significant for both the LAeq, 8h ($P = 0.304$) and LCpeak ($P = 0.607$).

Furthermore, majority, 71% (12 out 17), of area noise levels measured on specific lawn maintenance machines had equivalent continous A-weigted sound pressure level (LAeq) above the noise rating limit of 85 dBA. Machines measured in campus A had the highest area noise levels (LAeq) with mean noise levels of 98.8 dBA ±6.9, followed by campus B and C with mean noise levels of 92.9 dBA ±8.3 and 91.6 dBA ±5.1 respectively. The overall statistical difference in the mean area noise levels (LAeq) between the three campuses were found to be not significant (P = 0.135).

The findings of this study demonstrated that the study participants comprised a total of 18 males across the 3 campuses, with mean working experience in the current job of five (5) years (ranging 2 – 11 years). Majority (9 out of 18 or 50%) of the participants were aged between 36–45, while only 16% (3 out of 18) were above the age of 56. The distribution of the participants according to their education was 100% secondary school. This may have positive implications for understanding of information and training material used for noise exposure awareness.

The results of groundskeepers' awareness to certain elements of hearing conservation program, with specific focus to information and training, audiometric testing, and use of hearing protection devices (HPDs) revealed that majority (95%) of groundskeepers were not trained about the noise rating limit and its meaning as required by Regulation 4 of the NIHL Regulations. Furthermore, it was found that, 50% of groundskeepers indicated that they never received information and training on the health effects of noise exposure while working at the university. In terms of audiometric testing, 78% of groundskeepers indicated that they were given audiometric testing while employed at the university. The study further indicated that majority (63%) of groundskeepers reported that, they use hearing protection devices (HPDs) while operating noisy machines. Notably, 90% of groundskeepers reported that, there is no one who is checking and supervising if they wore HPDs while operating lawn maintenance machines. The analysis further shows that, 47% of groundskeepers reported that, their HDPs were not comfortable when worn.

Conclusion

The findings of this study have highlighted that, although the university had hearing conservation programs in place, there were shortcomings in the implementation of some elements of the program, in particular with regard to information and training, noise exposure monitoring and use of hearing protection devices. Most groundskeepers were exposed to noise levels exceeding the noise rating limit of 85 dBA and were at risk of acquiring NIHL. When

considering the peak noise levels, the results of the study showed that there was only one groundskeeper from campus A who was exposed to noise levels exceeding the peak limit of 140 dBC. In all cases, employees should never be exposed to peak noise levels in excess of 140 dBC. Prevention, by reducing the noise exposure via engineering measures should be prioritized. The peak noise exposure limit of 140 dBC is regulated in the European Union Physical Agents (noise) Directive 2003/10/EC (2003) as an upper exposure action value. This EU noise directive is adopted by most European countries. Currently in the South African NIHL Regulations and SANS 10083 standard, peak noise exposure levels are not regulated.

No significant differences were found in the mean area and personal noise levels measured in the three campuses. However, the use of certain machines such as backpack leaf blower and chainsaw were shown to be associated high noise exposure levels. Therefore, it is essential to ensure that noise levels on the lawn maintanance machines are significantly reduced by implementing good maintenance practices and buy quiet program. Information and training interventions should be aligned to target potentially exposed groundskeepers to modify their perceptions, noise control adherence approaches and continual motivation to sustain and improve an implemented hearing conservation program.

This is the first study in South Africa to evalaute occupational noise exposure among groundskeepers in a public univeristy. Findings from this study may contribute to existing knowledge on occupational noise exposure among groundskeepers and may be investigated by other universities where lawn mainteance machines are used. However, the findings of this study may not be generalized to other universities because the study was only conducted in one university. Lessons drawn from this study are that there is a greater need to enhance hearing conservation measures in gardening and landscaping services within the universities.