ORIGINAL ARTICLE

HEARING LOSS AMONG VECTOR CONTROL UNIT WORKERS IN BORNEAN MALAYSIA: A CROSS-SECTIONAL RISK FACTORS STUDY

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ABSTRACT

Risk factors related to hearing loss have been identified in many industrial workplaces. Nevertheless, despite the annual increment in hearing loss cases among vector control unit workers in Malaysia, risk factors associated with hearing loss among this population have not yet been measured properly. A cross-sectional study was conducted to determine factors associated with occupational hearing loss among Ministry of Health (MOH) vector control unit workers in Sabah from May to June 2020 involving 129 participants from three randomly selected district health offices. The data were collected via a validated self-administered questionnaire and audiometry test results and were analysed using IBM Statistical Package for Social Science (SPSS) version 26. Chi-square test, logistic regression, and multivariate analysis were used with p-value set at 0.05 with a 95% Confidence Interval (CI). The overall prevalence of hearing loss was 45.5% with a higher prevalence among the high-risk group (57.3%) than the low-risk group (12.5%). The difference was statistically significant ($p < 0.05$). Long duration of noise exposure (> 3 years) and high-risk group showed a significant association with hearing loss ($p < 0.05$) with the odds ratio of having hearing loss in workers with a long duration of noise exposure at 12.8 (95% CI = 4.02-40.5) while among the high-risk group it was 20.5 (95% CI = 3.98-105.1) when adjusted for age, smoking, and pesticide exposure. The results of this study can contribute to strengthen the implementation of risk controls to prevent further hearing loss among vector control unit workers.

Keywords: Occupational hearing loss, vector control unit workers, noise exposure, high-risk group, pesticide exposure, smoking, Sabah.

INTRODUCTION

Since the early 20th century, along with a boom in industrial development, many studies looking at the relationship between occupations and hearing loss have been conducted.[1] There are several risk factors involved in developing hearing loss in the workplace such as noise frequency, duration of noise exposure, safety behaviour, and ototoxic pesticide exposure.[2] Some of the factors can be prevented while others cannot. The prevalence of occupational hearing loss presented worldwide was found to be between 16% to 17%.[3] In Malaysia, cases of occupational hearing loss, investigated by the Department of Occupational Safety and Health (DOSH), have been increasing yearly.[4] In view of the increasing cases and outbreaks of dengue annually, and since it has become a public health concern, vector control unit workers have been increasing their workload in order to cover more areas. Subsequently, they are being exposed more frequently to the noise hazard emitted by fogging machines more frequently, which could result in hearing loss.

This is in addition to pesticide exposure from the machines. A study which was conducted in Malaysia reported that the overall prevalence of hearing loss among vector control unit workers was 16% and the sound level emitted from the fogging machine (Agrofog model) used was between 85 and 98 dB (A), which exceeded the permissible level.[5]

According to the Occupational Safety and Health Act 1994, it is important for employers to assess any possible types of occupational hazards in the workplace, and subsequently, to identify and control any health risk associated with the work.[6] In Malaysia, the awareness of the existence of occupational hazards in the workplace and safety measurements among employers and workers are still substandard. Not many studies have been conducted to look at the associated factors of hearing loss among vector control unit workers in Malaysia despite the annual increment of hearing loss cases in these vector control unit workers.[4]

Consequently, morbidity cases due to consistent exposure to hazards in the workplace have been increasing recently.[7] The US Occupational Safety and Health Administration (OSHA) mandates that employers provide a Hearing Conservation Program (HCP) which includes engineering

controls to reduce noise exposures, training for proper use of hearing protections, and annual audiometry tests.[8] A study revealed the impact of HCP where it improved employees' habits and awareness on hearing protection and noise induced hearing loss.[9] Hence, the implementation of this program among vector control workers should be crucially strengthened and acknowledged by the MOH Divisional Health Offices and local authorities. Therefore, this study aimed to determine the association of risk factors towards hearing loss among the vector control unit workers which may contribute to specific interventions of the risk factors, implementation of preventative actions, and building new policies. These may subsequently result in the reduction of occupational hearing loss cases.

METHODS

Study design & participants

A cross-sectional study was conducted involving vector control unit workers in the Bornean state of Sabah, Malaysia. Purposive random sampling was used to select three (3) district health offices randomly. All the MOH vector control unit workers were chosen from the selected districts. In view of the Covid-19 Movement Control Order (MCO), the districts were selected based on the availability of audiologists and audiometry facilities at the districts as well as their accessibility by car.

The sample size was based on the prevalence of a previous study where a 95% Confidence Interval (CI) was chosen with 5 degrees of precision allowed and level of statistical significance was 1.96.[5] After considering the adjustment for non-response rates of 20 percent, 183 samples were determined as required for this study, but eventually, only 129 eligible samples that fulfilled the inclusion criteria were enrolled in this study.

Variables

Noise exposure refers to the situation where the participants are exposed to a high level of noise (> 85 dB) emitted from the fogging machine (model Agrofog, type AF 35). Chemical exposure is the situation where the workers have been exposed to pesticides before. Lack of safety behaviour refers to the improper use of personal protection equipment (PPE), insufficient knowledge and awareness about the risk exposures and inadequate hygiene practices by the participants. Long exposure to noise refers to the situation where the participants have been exposed to a high level of noise for more than three years.[10,11] The participants were diagnosed for sensorineural hearing loss (SNHL) either unilaterally or in both ears when their hearing threshold level (HTL) was more than 25 dB (A) at 500, 1000, 2000, 3000, 4000, 6000, or 8000 Hz by Pure Tone audiometry test. The hearing threshold shift adjusted for age and gender was according to the international standard of ISO 1999:2013. In this study, the participants were categorised into low-risk and high-risk groups. The low-risk group consisted of participants who were mainly involved with administrative work and were seldomly exposed to the hazards, whereas the high-risk group consisted of those who were continuously exposed to hazards daily for at least 3 hours.

Eligibility criteria

The participants were taken as eligible for this study when they met the following criteria: aged between 20 and 55 years old, fulltime workers under the MOH, and willing to participate. Participants were excluded if they had ear infection, perforated tympanic membrane, chronic illnesses, clinical history of deafness, or if they were part-time workers.

Instrument and Data collection

The research tools employed in this study included consent form, self-administered questionnaire, Pure Tone Audiometry machine, and Sound Level Meter (SLM) machine.

The data was collected from May to June 2020 at the respective district health offices. The questionnaires were filled up by the participants after written consent was obtained followed by otoscopic examination and audiometry test. The audiometry machines used were calibrated according to the prevailing standards and the tests were conducted by expert audiologists in a designated soundproofed room which complied with the Factories and Machinery Noise Exposure Regulation 2019. A Larson Davis SLM machine was used to determine the noise mapping at eight (8) points from the fogging machine (Agrofog fogging machine, type AF 35) in a grid pattern.

Data analysis

The data were analysed using SPSS version 26. A Chi-square test was used to determine the association between independent variables and hearing loss. Binary logistic regression and multivariate analysis were performed to determine the association between risks and hearing loss. The risks were estimated using Odds Ratio (OR) with a 95% Confidence Interval (CI) and p-value of < 0.05 was accepted as statistically significant.

Ethical Clearance

This study was conducted with the approval from the Malaysian Research Ethics Committee [NMRR-19-3735-52423 (IIR)], the Ministry of Health Malaysia and the Research Ethical Committee of Faculty of Medicine and Health Science, University Malaysia Sabah [JKEtika 1/20 (22)].

RESULTS

A total of 121 eligible participants from three (3) selected districts were involved in this study and

8 participants were excluded, as they were found to have perforated tympanic membrane, otitis media, and ear discharge.

Table 1 shows the socio-demographic information of the participants. The majority of the participants were male workers (N = 112, 92.6%), Bumiputera Sabah (N = 109, 90.1%) where most of them were Kadazan Dusun, aged 26 to 35 years old (N = 60, 49.6%), non-smokers (N = 94, 77.7%), with low educational background (N = 82, 67.8%) and earned between RM1000 and RM3500 (N = 112, 92.6%) with a mean of RM2719.01.

Based on the frequency distribution of the factors involved in this study, 45.5% of the participants were exposed to noise hazard, 54.5% of the participants were exposed to noise hazard for a long time period, 77.7% of them were exposed to pesticides, and 32.2% of the participants had lack of safety behaviour. Most of the participants were in the high-risk group (73.6%) while others were in the low-risk group (26.4%).

The overall prevalence of hearing loss among vector control unit workers was 45.5%, with a higher prevalence among the high-risk group (57.3%) than the low-risk group (12.5%). The difference was statistically significant ($p < 0.001$). Socio-demographically, only smoking had a significant association with hearing loss ($p < 0.05$), and among all factors involved, two variables had a significant association with hearing loss; these were duration of noise exposure (> 3 years) and chemical exposure with $p < 0.05$ for both factors. Table 2 shows the proportion of hearing loss according to socio-demographic, independent variable, and risk group. By using binary logistic regression, 69% of participants aged ≤ 40 years were significantly less likely to get hearing loss (Crude OR = 0.309, 95% CI = 0.14-0.71, $p < 0.05$). Meanwhile, participants who were smokers (Crude OR = 3.83, 95% CI = 1.52-9.65, $p < 0.05$), who were in the high-risk group (Crude OR = 9.40, 95% CI = 3.04-29.04, $p < 0.01$), who had experienced noise exposure of > 3 years (Crude OR = 14.53, 95% CI = 5.79-36.5, $p < 0.01$), and who were exposed to pesticides (Crude OR = 6.82, 95% CI = 2.19-21.3, $p < 0.01$) were found to have significant hearing loss.

Based on the multivariate analysis (Table 3), the odds of having hearing loss was 12 times higher in the duration of noise exposure of > 3 years group compared to the ≤ 3 years group (95% CI = 4.02-40.5, $p < 0.01$). The odds of having hearing loss in the high-risk group was 20 times higher compared to the low-risk group (95% CI = 3.98-105.1, $p < 0.01$) when adjusted for age, smoking, and pesticide exposure.

Noise mapping showed that the distance which produced noise ≥ 85 dB (A) was 3.0 to 5.0 metres, ≥ 90 dB (A) was at a distance of 1.5 to 3.0 metres, ≥ 95 dB (A) was at a distance of 1.0 to 1.5 metres and ≥ 100 dB (A) was at a distance of 0.5 metres.

Table 1: Summary of frequency distribution of socio-demographic and socio-economic status

Variables	Distribution	Total (%)
Sex	Male	112 (92.6)
	Female	9 (7.4)
Age	16-25 years old	6 (5)
	26-35 years old	60 (49.6)
	36-45 years old	38 (31.4)
	> 45 years old	17 (14)
Race	Bumiputera Sabah	109 (90.1)
	Non-Bumiputera Sabah	12 (9.9)
Education level	Primary school	4 (3.3)
	Secondary school	78 (64.5)
	Diploma	32 (26.4)
	Degree	7 (5.8)
Income	RM1000-RM3500	112 (92.6)
	RM4000-RM6500	9 (7.4)
Smoking status	Yes	27 (22.3)
	No	94 (77.7)

N = 121

Table 2: Proportion of hearing loss according to socio-demographic, independent variable, and risk group

Variable	Hearing loss, N(%)		X^2 (p-value)	Crude OR (95% CI)
	Positive	Negative		
Age				
≤ 40 years old	32 (37.2)	54 (62.8)	8.125	0.309
> 40 years old*	23 (67.5)	12 (34.3)	(< 0.05) +	(0.14-0.71)
Race				
Bumiputera Sabah	51 (46.8%)	58 (53.2)	0.789	1.76
Non-Bumiputera Sabah*	4 (33.3%)	8 (66.7%)	(0.543)	(0.5-6.19)
Sex				
Male	52 (46.4)	60 (53.6)	0.576	1.73
Female*	3 (33.3)	6 (66.7)	(0.345)	(0.41-7.28)
Monthly income				
RM1000-RM3500	48 (42.9)	64 (57.1)	4.097	0.21
RM4000-RM6000*	7 (77.8)	2 (22.2)	(0.077)	(0.04-1.08)
Education level				
Low education	40 (48.8)	42 (51.2)	1.135	1.52
High education*	15 (38.5)	24 (61.5)	(0.332)	(0.70-3.31)
Smoking				
Yes	19 (70.4)	8 (29.6)	8.702	3.83
No*	36 (38.3)	58 (61.7)	(< 0.05) +	(1.52-9.65)
Exposed to noise hazard > 85 dB				
Yes	48 (47.5)	53 (52.5)	1.056	1.68
No*	7 (35.0)	13 (65.0)	(0.304)	(0.62-4.57)
Long duration of noise exposure, > 3 years				
Long	47 (71.2)	19 (28.8)	38.854	14.53
Short*	8 (14.5)	47 (85.5)	(< 0.01)+	(5.79-36.5)
Exposed to chemical hazard/pesticides				
Exposed	51 (54.3)	43 (45.7)	13.160,	6.82
Not exposed*	4 (14.8)	23 (85.2)	(< 0.01) +	(2.19-21.3)
Lack of safety behaviour				
Lacking	19 (48.7)	20 (52.3)	0.247	1.22
Good*	36 (43.9)	46 (56.1)	(0.619)	(0.57-2.61)
Risk group				
High-risk	51 (57.3)	38 (42.7)	19.056	9.40
Low-risk*	4 (12.5)	28 (87.5)	(< 0.01) +	(3.04-29.04)

*N = 121, *Reference category, +p-value < 0.05*

Table 3: Prediction of hearing loss based on multivariate analysis

Variable	ß-coefficient	SE	Adjusted OR	95% CI	p-value
Duration of noise exposure					
> 3 years	2.55	0.59	12.8	(4.02-40.5)	< 0.01*
≤ 3 years					
Risk group					
High-risk	3.02	0.84	20.5	(3.98-105.1)	< 0.01*
Low-risk					
Constant	- 4.01	0.912	0.018		< 0.01*

*N = 121, *p-value < 0.05, Nagelkerke = 0.553*

DISCUSSION

Noise and chemical hazards have been identified to be associated with hearing loss among vector control unit workers based on previous studies.[5,12] Chronic exposure to these hazards may cause persistent damage to the hair cells and hearing conduction nerves, and eventually, cause sensorineural hearing loss.[13]

A higher prevalence of hearing loss was found among the high-risk group (57.3%) which corresponded with a previous study.[14] The high-risk group includes workers who had daily exposure to the potential risk factors towards hearing loss such as handling pesticide mixture for space spraying, thermal fogging, Ultra-Low Volume (ULV) aerosols, mist fogging, indoor residual spraying, chemical larviciding, and insecticide-treated bed nets, as compared to the low-risk group of workers who were seldom exposed to the risk factors towards hearing loss.[15] Furthermore, the results showed a significant association between pesticide exposure and hearing loss which corresponded with the previous study.[16]

Noise emitted from the fogging machine produced a noise level of > 85 dB (A) by using SLM; these were similar findings with a previous study.[5,12] Although this study was unable to associate noise exposure of > 85 dB with hearing loss, there was a variation in the distance between a worker and the fogging machine as well as the variation in the duration of exposure which could determine the chances of getting hearing loss.[17] High-risk workers who were frequently involved in fogging activities, for a long time duration, and at a short distance from the noise, had higher chances of getting hearing loss. Noise mapping elucidated that high-risk workers were exposed to noise of > 100 dB (A) emitted from the fogging machine which exceeded the noise exposure limit (NEL) according to the Factories and Machinery Noise Exposure Regulations 2019.[18] These findings are very important as they will determine how long should a worker be allowed to be exposed to the noise. Based on OSHA, the recommended exposure time for noise > 85 dB (A) is eight hours and for noise > 100 dB (A) the recommended exposure is two hours.[19] In addition, a previous study was done which showed a correlation between repeated high noise exposure in a short duration and noise-induced hearing loss.[20]

A significant relationship between an extended duration of exposure to noise and hearing loss was comparatively identical with previous studies [5,21] which elucidated that vector control unit workers who worked for more than 3 years have a higher risk of getting hearing loss. Many of the workers had been exposed to noise for years based on their years of service, and most of them were involved with fogging activities for ≤ 3 hours. In this case, it was revealed that long-term service with continuous exposure to noise of > 85 dB (A) could also increase the likelihood of getting occupational noise-related hearing loss.

Furthermore, based on a previous study, there was a significant association between pesticide exposure and hearing loss. It has been shown that pesticides used in vector-control activities, such as organophosphate (malathion) and pyrethroid had ototoxic effects which eventually can cause hearing loss.[16] This is supported by salient research findings which mentioned the ototoxic effects of organophosphates on hearing loss, whereby it affects the cochlea by damaging cellular and hair cells through reactive oxygen generation.[22,23,24] Workers can be exposed to both organophosphate and pyrethroid during preparation before fogging or spraying (mixing and transferring the pesticides) as well as during the fogging or spraying activities.[15] Hence, it is crucial to identify according to sections, the working process involved, and to understand the mechanism or toxicokinetic of the pesticide exposure to the workers. The route of entry to the human body which can cause hearing loss can be determined through a special audit by a designated occupational health team. These audits ca be conducted routinely. Another way to regularly monitor pesticide exposure is by measuring the workers' blood cholinesterase levels.

Hierarchy of control has been shown conclusively as the best method to determine the effective control measures ranging from the most effective way to the least effective way.[25] Ideally, noise hazards coming from the fogging machine can be reduced using a few ways. One of the best options is to substitute the noisy fogging machine with a new low-noise fogging machine.[26] It is recommended that the substitution be done in stages and the noisy fogging machine be slowly phased out. Another possibility that could be more cost-effective is to change or replace parts of the fogging machine that produce loud noise with noise-reduction tools that can reduce the sound significantly.[27] Apart from the measures above, engineering control can also be done such as lubricating the machine using oil lubricants and enclosing the fogging machine with a sound absorbent material.[28]

Through administrative control assistance, hearing loss due to long exposure to noise can also be reduced.[29,30] It is vital for the vector control unit workers to be divided into two working shifts, and for the employer to carry out at least a half-yearly internal job shifting or job rotation of the workers to other units in the health offices to reduce the exposure to noise and chemical hazards among the workers.[31] Furthermore, in parallel with the provisions of Noise Regulation 2019, strengthening the regulation on the Hearing

Conservation Program (HCP) can also be established at all health offices, using the practice code for occupational noise exposure management together with a designated program implementer to monitor the HCP program.[32]

Strengths

Although hearing loss is still significant among vector control workers who have been continuously exposed to noise and chemical hazards, this is the first time a study has been conducted on the MOH vector control unit workers in Sabah. The outcome will be highly beneficial to their overall hearing health especially in identifying the leading causes of hearing loss in the workplace, so that the trend of escalating work-related hearing loss could be controlled. Furthermore, in terms of reliability and validity, this study included multiple factors such as physical (noise), chemical, and safety to detect the risk factors of occupational hazards related to hearing loss. This study also utilised quantitative assessment involving noise mapping to detect the level of noise exposure as well as pure tone audiometry testing to detect sensorineural hearing loss. In addition, the audiometry test was conducted by expert audiologists who are certified in administering the test to ensure the validity of the tests conducted.

CONCLUSION

The overall prevalence of hearing loss among vector control unit workers was found to be 45.5%. This percentage is higher than the world prevalence of work-related hearing loss. The vector control unit workers have been increasingly exposed to the noise and chemical hazards while working in fogging operations due to high vector-borne disease case numbers. Cases of work-related diseases, particularly hearing loss, have become a great concern. Hence, all possible risk factors need to be anticipated to prevent the workers from getting occupational hearing loss at their workplace. This study revealed that hearing loss was associated with a high-risk group and noise exposure of > 3 years. These days, noise can no longer be considered a particular hazard that causes work-related hearing loss as workers are also being exposed to other hazards which could also contribute to hearing loss.

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Conflict of Interest

The authors declare that they have no conflict of interests.

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