

Noise-induced hearing loss among manufacturing factory workers in Kuching, Sarawak: Prevalence and associated risk factors

Halim Ismail, DrPH, Azizul Idris, MScCH, David Chan Chee Hoong, MPH, Hanis Ahmad, MPH, Hafiz Baharudin, MPH, Naiemy Reffin, MScCH, Hibatul Hakimi Jamaludin, MD, Nor Azila Aris, MD, Huam Zhe Shen, MD

Department of Public Health Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia

ABSTRACT

Introduction: Noise-induced hearing loss (NIHL) is a common problem worldwide. Increased globalisation, as well as industrialisation, gives rise to an increase in the incidence of NIHL worldwide. Malaysia is not spared from this problem, either. The objectives were to determine the prevalence of NIHL and its associated factors among manufacturing factory workers.

Material and Methods: A cross-sectional study was done in Kuching, Sarawak, involving 173 randomly selected respondents among manufacturing factory workers. Data collected were respondents' workplace monitoring data and their audiometry records obtained from the factory record, and the otoscopy examinations performed. In addition, respondents were required to fill up an interviewer-guided questionnaire.

Results: The prevalence of NIHL was high (49.7%). The factors which were found to have a significant association with NIHL in bivariate analysis were age ($p < 0.05$, 95% CI), male gender ($p < 0.05$; OR – 7.60; CI 3.34 – 18.38), duration of employment ($p < 0.05$), knowledge of noise level ($p < 0.05$; OR – 4.11; CI 1.10 – 15.28), working at polishing department ($p < 0.05$; OR – 4.23; CI 2.13 – 8.43), and smoking ($p < 0.05$; OR – 39.6; CI 16.5 – 94.8). Pack-years of smoking were also found to have a significant association with $p < 0.05$. However, only smoking was statistically significant in multivariate analysis, where the risk of developing NIHL was 27.55 ($p < 0.005$; CI 10.74 – 70.64) among smokers.

Conclusion: The high prevalence of NIHL despite the existing Hearing Conservation Program (HCP) may indicate that there may be some elements in HCP that require close monitoring by the factory management, and the importance of smoking cessation among the workers exposed to noise at the workplace should be highlighted.

KEYWORDS:

Noise-induced hearing loss, manufacturing factory, audiometry, prevalence, Sarawak

INTRODUCTION

Occupational noise-induced hearing loss (NIHL) is a prevalent occupational disorder, and hearing loss caused by

workplace noise exposure is a significant health issue globally.¹ NIHL occurs due to long-term exposure to excessive noise, usually over the years. Therefore, continuous or intermittent noise in the workplace that exceeds 85dB(A) during an 8-hour shift, or impact noise that exceeds 120dB(A), is deemed dangerous.^{1,2}

Globally, NIHL is responsible for 16% of cases of debilitating hearing loss in adults, indicating that it does not directly cause early death but does result in significant disability.^{2,3} In Malaysia, occupational NIHL, which includes NIHL, hearing impairment, and Permanent Standard Threshold Shift, was the most frequently reported occupational disease in 2021, accounting for 3648 cases (68.9%).⁴ Although the data may not reflect the entire Malaysian population, it is clear that NIHL is a significant concern impacting many employees in Malaysia.

NIHL is related to multiple factors, and the risk factors for developing NIHL can be non-modifiable such as age and gender, or can be modifiable. In addition to occupational noise, other causes (such as organic solvents, high temperatures, lack of hearing protection devices, smoking, alcohol, heredity, comorbidities) may serve independently or synergistic effects with noise to increase the risk of NIHL.⁵⁻⁶ Tobacco smoking is a risk factor for various diseases, and several scientific literatures has shown that it may be related to NIHL.⁷⁻⁹ Some toxic and harmful substances like nicotine from tobacco burning may affect hearing.¹⁰ Smokers were almost twice as likely as non-smokers to develop hearing loss. This association persisted in studies that excluded those with non-age-related hearing loss and those with no history of occupational noise exposure.^{10,11} Several meta-analysis studies have found evidence of an association between cigarette smoke and hearing loss.¹⁰⁻¹²

The intensity, frequency, duration of exposure, and type of noise significantly impact the risk of health hazards, notably occupational hearing loss. Individuals with NIHL may endure severe morbidity due to hearing loss, concomitant tinnitus, and poor speech discrimination.¹³ Non-auditory effects may impacts workplace communication and safety. The non-auditory reaction to noise may be affected by sound qualities such as the rate, loudness, consistency, complexity, duration (period of exposure) and noise meaning.¹⁴ Noise has been linked to increased stress, cardiovascular health

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Corresponding Author: David Chan Chee Hoong

Email: davidcch10@gmail.com

(hypertension, changes in heart rate), irritation, poor sleep and mental health issues. Because of this broad spectrum of impacts, experts believe noise can interact as a general, non-specific stressor.¹⁴⁻¹⁵ Studies have proved that a sound pressure level of 95-90 dB(A) can induce hearing loss of more than 25 dB(A), whereas a sound pressure level of 85-90 dB(A) can cause hearing loss of less than 2dB(A).¹⁶ The risk of NIHL can be minimised if noise is decreased to below 80 dB(A). Regulation six of the Occupational Safety and Health (Noise Exposure) Regulations 2019 states that the NEL as the daily noise exposure level should not exceed 85dB(A) or daily personal dose (cumulative noise exposure of an employee corrected for a typical working day of eight hours) a hundred per cent (100%). The criterion for maximum sound level pressure (SPL) exceeding 115dB(A) at any time or the peak SPL exceeding 140dB(C) necessitates the implementation of activities to reduce risk of NIHL. This dose limit uses a 3-dB time-intensity trade-off as the exchange rate.^{2,18}

A thorough medical history can assist in establishing whether any of these disorders may be contributing to an individual's hearing loss.^{2,17,18} Poor knowledge and awareness among employees and a lack of enforcement by governing bodies were cited as factors for the risk of NIHL. In addition, hearing protection is not often adequately fitted, and even when it is, it wears out and fails to provide the specified laboratory values of attenuation in the field.^{17,18}

Research showed that occupational noise exposure is a significant concern and pervasive in the industrial industry.¹⁹ Processing tasks are a significant aspect of the manufacturing industry, and the complexity of process noise such as forging, grinding, cutting, polishing, and welding is very noticeable.²⁰ Although the reported NIHL cases have dramatically increased since 2010, there is a significant disparity between the number of cases diagnosed and the number of workers exposed to hazardous noise. In addition, there is no established data on NIHL among manufacturing sector workers in Sarawak. Therefore, this study aims to determine the proportion of NIHL and its associated factors among manufacturing factory workers.

MATERIALS AND METHODS

Study design

This retrospective cross-sectional study was conducted among manufacturing factory workers in Sarawak to evaluate the medical record, area monitoring, personal monitoring, and workers' audiometry assessment from the factory records.

This research has been approved by UKM ethical committee (UKM FPR.4/244/FF-2016-219) and the manufacturing company management board.

Study subject and methods

This study included all workers from the polishing and plating department of the manufacturing factory who went for an annual audiometry assessment and were exposed to noise at work above noise exposure limits (NEL) of 85 dB(A). However, workers who have underlying medical diseases that may compromise blood flow to organs and increase viscosity, like diabetes mellitus, hyperlipidaemia, and hypothyroidism,

history of usage of the ototoxic drug, history of severe and frequent ear infections with or without ear surgery were excluded from the study. Additionally, workers with a history of exposure to non-occupational noise, such as involvement in the war, and loud explosion activities, such as hunting, were excluded.

Eligible workers were selected by a simple random sampling method, where each subject was chosen randomly and by chance.

Selected respondents then undergo an otoscopic examination and audiometric assessment. Those with abnormal otoscopic findings such as ear wax, ear discharge, perforated tympanic membrane, and ear infection were ruled out from the study. An audiometry assessment was conducted for selected workers after they were not exposed to noise for 14 hours before the test. Furthermore, all respondents were using hearing protective devices uniformly as they worked in an area requiring hearing protection before entry.

Factors such as age, gender, duration of working, working department in the company, smoking habits (packed year), knowledge of noise level of the workplace unit, and usage of hearing protective devices were obtained through a sociodemographic questionnaire.

Written and oral informed consent was obtained from all participants. They were assured anonymity as well as confidentiality.

Diagnosis of NIHL

1. History taking and physical examination

To ensure that the NIHL was caused by the current employment and not due to previous job exposure or other non-occupational exposure, several histories such as medical, non-occupational, previous employment, drugs, recreational and social histories of exposure risk in the history taking were included in the sociodemographic questionnaire. History of hearing loss, ear pain, ear discharge, head injury, history of tinnitus, recent surgery on ear, nose, and throat, or head surgery was considered. Hobbies that involve noise exposure, such as loud music, clubbing, hunting, and scuba diving as a hobby were documented.

Respondents underwent a thorough head, ear, neck and cranial nerve examination and an otoscopic examination.

2. Audiometric assessment

There must be a positive history of exposure to noise at the workplace. Audiometric examination results were used to determine hearing loss among the respondents. The audiometric results should have a hearing threshold of more than 25 dB(A) at 4 kHz with a characteristic dip followed by recovery at higher frequencies to determine whether hearing loss was related to noise exposure. The dip depth in NIHL alone should not be more than 75 dB(A) in higher frequencies and should not be more than 40 dB(A) in lower frequencies. If those dips were not consistent with the characteristic of noise exposure, then the hearing loss could be due to other factors such as presbycusis.

Table I: Sociodemographic characteristics of respondents (n = 173)

Variables	Frequency (n)	Percentage (%)
Age group		
20 – 24.9	51	29.5
25 – 29.9	54	31.2
30 – 34.9	42	24.3
35 – 39.9	21	12.1
40 – 44.9	2	1.2
≥ 45	3	1.7
Gender		
Male	131	75.7
Female	42	24.3
Duration of employment		
1 – 4.9	116	67.1
5 – 9.9	38	22.0
10 – 14.9	10	5.8
15 – 19.9	2	1.2
≥ 20	7	4.0
Department		
Plating	58	33.5
Polishing	115	66.5
Noise level knowledge		
Yes	14	8.1
No	159	91.9
HPD usage		
Yes	36	20.8
No	137	79.2
Smoking history		
Yes	82	47.4
No	91	52.6
Pack – years+		
< 0.9	106	61.3
1 – 4.9	37	21.4
5 – 9.9	25	14.5
10 – 14.9	3	1.7
≥ 15	2	1.2

HPD = Hearing protective device

+ smoking was quantified based on pack years which are calculated based on the number of cigarettes per day times the years of cigarette consumption.

Table II: Prevalence of NIHL

	Frequency (n)	Percent (%)
Yes	86	49.7
No	87	50.3
Total	173	100.0

Table III: Association between gender, previous employment, department, noise level knowledge, hearing protective device usage, smoking, and NIHL

Variables		NIHL (%)		C ² value	p value
		Yes	No		
Gender	Male	79 (60.3%)	52 (39.7%)	24.22	< 0.001*
	Female	7 (16.7%)	35 (83.3%)		
Previous employment	Yes	5 (45.5%)	6 (54.5%)	0.085	0.77
	No	81(50.0%)	81(50.0%)		
Department	Plating	42 (72.4%)	16 (27.6%)	17.99	< 0.0005*
	Polishing	44 (38.3%)	71 (61.7%)		
Noise level knowledge	Yes	11 (78.6%)	3 (21.4%)	5.08	0.024*
	No	75 (47.2%)	84 (52.8%)		
Hearing protective device usage	Yes	20 (55.6%)	16 (44.4%)	0.62	0.43
	No	66 (48.2%)	71 (51.8%)		
Smoking	Yes	72 (87.8%)	10 (12.2%)	90.49	<0.0005*
	No	14 (15.4%)	77 (84.6%)		

* Statistically significant p < 0.05

Table IV: Association between age, duration of employment, pack-years and NIHL

Variables	NIHL	N	Mean ± Std. deviation	t-test, (t)	p value
Age	Yes	86	30.69 ± 7.19	3.902	<0.001*
	No	87	27.02 ± 4.97		
Duration of employment	Yes	86	5.71 ± 5.39	4.05	<0.0005*
	No	87	3.15 ± 2.37		
Pack-years	Yes	86	3.44 ± 3.36	8.62	<0.0005*
	No	87	0.22 ± 0.86		

*Statistically significant $p < 0.05$

Table V: Multiple logistic regression between variables and NIHL

Variables	aOR	p value	95% C.I. for OR	
			Lower	Upper
Age	0.98	0.70	0.91	1.07
Smoking*	27.55	0.00	10.74	70.64
Gender	2.42	0.13	0.778	7.50
Noise level knowledge	1.37	0.72	0.242	7.73
Department	2.37	0.09	0.874	6.43

*Statistically significant $p < 0.05$

Statistical analysis

Data analysis was done with Statistical Package for Social Sciences (SPSS) version 22. The statistical test used was Pearson's Chi-Square test, and if there were any cells with an expected value less than 5, a Chi-square test with Yates correction was performed. For qualitative data with quantitative binominal data, student t-tests were done. Two-tailed p values were calculated, and the p value of <0.05 were considered to have a significant association. Multivariate analysis using multiple logistic regression (MLR) with forward and backward stepwise analysis was used to determine the final model of this study.

RESULTS

A total of 298 respondents participated in this study. Of these 298 respondents, 125 were excluded from further analysis because they did not fulfil the inclusion criteria.

Regarding sociodemographic characteristics, as shown in Table I, most respondents were in the 25 to 30 age group (31.2%). The mean age of the respondents was 28.84 ± 6.42 years, where the youngest respondent was 21 years of age and the oldest was 54 years of age. Most were male workers (75.7%), the majority with a duration of employment between 1 to 5 years. Most respondents were from polishing department (115, 65%), while the rest were from plating department. These represent two of the significant activities in the manufacturing company.

Regarding duration of smoking, less than half of the respondents were smokers, 82 respondents (47.4%), and their mean duration of smoking was 3.94 ± 5.54 years. On the other hand, the mean pack – years calculated was 1.82 ± 2.92 , and the majority of the respondents (61.3%) had pack – years of less than 0.99.

A high percentage of the workers (80.5%) have a normal otoscopy finding, and only 2% have perforated ear drums.

The overall prevalence of hearing loss in this manufacturing company was 49.7%, as shown in Table II.

The bivariate analysis has shown that males workers ($\chi^2=24.22$, $p<0.001$) in the plating department ($\chi^2=17.99$, $p<0.05$) are more likely to develop NIHL (Table III). Smokers were found to have a higher risk (unadjusted Odds Ratios, OR = 39.6; CI = 16.5–94.8) of developing NIHL than those who did not smoke. The difference was statistically significant (p value < 0.05). In pack – years, those with the higher pack–years of smoking were likelier to develop NIHL than those with lower pack – years (Table IV).

In the multiple logistic regression, only smoking was statistically significant with an adjusted OR of 27.55 (95%CI 10.74 – 70.64). Despite other variables having statistically non-significant results, males are two times more likely to develop NIHL than females. In addition, those who do not know the noise level are one time more likely to develop NIHL than those who know the noise level, and those in polishing department are twice more likely to develop NIHL compared to plating department after adjusting with others risk factors (Table V).

DISCUSSION

The study was done on a population of manufacturing factory workers involving 298 workers. However, only 173 respondents were eligible to be included after the exclusion. This study found that the prevalence of NIHL in this company was as high as 49.7%. It was similar to other researchers who found a high prevalence of NIHL in various industries in Asia and Malaysia.²³⁻²⁵

Age is one of the vital factors found in other research and has a statistical significance in this research, too. It proves that the older the person, the more likely she or he is to develop NIHL. This is consistent with other research showing that older people are more likely to develop NIHL. However, in

NIHL, it differs from age-related hearing loss (AHL), which appears later, as in NIHL, it appears in younger age groups. If other parameters are excluded, age can also be the most important single factor for NIHL.²⁶ Young age group distribution may be exposed enough to noise higher than PEL for a considerable time, thus giving an early diagnosis of NIHL.

Furthermore, the working group is primarily young and fit, likely to get employed and stay employed (Hawthorne's effect). NIHL differs as it develops earlier in adults exposed to noise than age-related hearing loss (presbycusis).²⁷ A young person exposed to noise shows a threshold shift compared to an older person who does not show any threshold shift, as postulated in some research. This explains the younger group population who developed NIHL in this study.²⁸

Gender is important in developing NIHL, as male workers are more likely to be employed in manufacturing industries. However, few other studies also replicate that male predominance.^{29,30} Hearing sensitivity also declines in men twice as fast as women of the same age and found longitudinal declines in hearing sensitivity at 30 compared to women, which is seen at a later age.²⁹ Furthermore, lifestyle habit, such as smoking, is more common in males than in females.

Duration of employment indicates when the person is exposed to noise and predisposed to NIHL. The longer the person is exposed to noise, the more likely they will develop NIHL. Duration of employment indicates dose—response relationship, thus corresponding with this research's findings.^{28,31} The previous history of employment in a noisy environment was not statistically significant. This is probably because most workers employed at this manufacturing company are young, which is probably their first job. Plating department was statistically significant in developing NIHL compared to polishing department, although both departments are exposed to noise above NEL. That may be partly due to lacking control at the source as well. Workers aware of the NEL are more likely to develop NIHL than those not aware of the NEL. This is because those diagnosed have been told about their findings and made aware of the noise level. This contrasts with a study that indicates that those unaware of noise levels are more likely to develop NIHL.³²

Knowledge is an essential aspect of the Hearing Conservation Program (HCP). Although some research showed that the workers' knowledge of hearing conservation was good,³² research in Malaysia shows that the knowledge, usage of Hearing Protective Devices (HPD), and attitude towards NIHL prevention were low.^{25,33} Although 23.3% of the workers wore HPD at work, they may not have worn it correctly and thus did not offer complete protection compared to properly fit HPD. Properly fit HPD may attenuate 15–20 dB (A).²⁶ Furthermore, this was also proven during the walkthrough survey that most workers were non-compliant in wearing HPD due to a long time of usage and lack of social communication. However, using HPD on an average of 50% of the time also offers protection compared to those who did not wear HPD.³⁴ There could be a lack of knowledge regarding the importance of hearing conservation among the workers, and some may not adhere to it entirely—for example, proper

usage of PPE and exchange of PPE once it is spoiled or damaged.

This study proves the hypothesis that there is a significant relationship between smoking and NIHL and pack-years of cigarette consumption. Smoking is a lifestyle habit that predisposes its users and those surrounding them to multiple health hazards. Cigarette smoke lacks an antioxidant effect, where reports that endogenous antioxidants significantly influences susceptibility to auditory damage.³⁵ Therefore, it is probable that the number of endogenous antioxidants in smokers is reduced, thus predisposing them to cochlear damage. Other researchers also found that smoking and hearing loss is statistically significant in those exposed to occupational noise with OR 1.85, 95% CI 1.33–2.57, and pack-years of smoking remained significantly associated with hearing loss.³⁶ The precise mechanism of smoking and NIHL is unknown. A simple additive effect of smoking and noise might be compatible with NIHL potentiation caused by long-term exposure to excessive noise and carbon monoxide exposure from smoking. Nicotine and other tobacco compounds could be ototoxic.^{36,37} The fundamental pathologic processes are the established vascular changes (cochlear hair cells damaged by raising carbon monoxide haemoglobin, cochlear hypoxia, capillary vasoconstriction, or decreasing cochlear blood flow volume) associated with smoking as well as long-term exposure to loud noise.³⁶⁻⁴¹ Evidence suggests synergistic effects of smoking, noise, and age on hearing loss and a multiplicative effect of smoking and age on hearing loss. Some other studies also found that median age-corrected hearing thresholds at 3 and 4 kHz in smokers are significantly higher [7 dB (A)] than in those who do not smoke.^{36,37}

This study has achieved its objectives and proved most of its hypotheses, as this manufacturing company reveals the prevalence of NIHL in almost half of the workforce. This study also manifests that the HCP, which this manufacturing company has implemented, may not be as effective as they are still weak areas of compliance. Although the seven elements of HCP have been adhered to, they may not be enough, especially on the worker's part.

The main limitation of our study was the small sample size. The targeted sample size was not achieved as turnout was not as expected, as the study was done during regular working hours, and they followed shift and team systems. In addition, the secondary data may influence the audiometric result as it can be operator dependent. Furthermore, the instructions given to the respondents may not be accurate and thus may reflect misclassification bias. Hawthorne's effect, most of the employees are young as the young and fit are most likely to be employed and remain employed. Thus, the sample population is mainly of the young age group of less than 45 years.

CONCLUSION

The study found that occupational noise exposure is a severe hazard, mainly distributed in the manufacturing industry, with the complexity of the process noise, such as forging, grinding, cutting, and welding, particularly prominent. The rising trend in Malaysia over the past few years is probably

due to the increasing nature of investments and government initiatives for small and medium-scale industries. Other than the increasing nature of industries entering Malaysia, other factors could contribute to increased cases, such as poor compliance towards HCP. Smoking cessation programmes need to be incorporated, and the benefits are of a broad range as well. Reward or merit can be given to those who successfully stopped smoking and helped reduce the incidence and prevalence of NIHL.

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