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PREDICTORS OF AIRCRAFT RELATED NOISE INDUCED HEARING LOSS (NIHL) AMONG TECHNICIANS IN ROYAL MALAYSIAN AIR FORCE (RMAF)

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ABSTRACT

Background: Noise-induced hearing loss (NIHL) is one of the most common occupational illnesses in Malaysia. This study was intended to assess the predictors of NIHL among Royal Malaysian Air Force aircraft technicians.

Materials and Methods: A cross sectional study was conducted in Butterworth Air Base. Respondents were selected based on simple random sampling and the sample size estimation calculated using two proportion sample size formulation. Instruments used in this study including a set of questionnaire; a sound level meter; a personal dosimeter; and a pure tone audiometry. Data was analysed using IBM Statistical Package for Social Science (SPSS) version 21.0 and level of significance at $P<0.05$.

Result: There were 263 (80.2%) respondents with the response rate of 80.2%. The mean age of the respondents was 31.98 ± 4.81 year old. Personal noise dosimeter showed that time weighted average, TWA_8 for respondents in 3Sqn was 93.2±2.0 dB(A), 15Sqn was 112.0±5.2 dB(A) and 18Sqn was 118.1±3.6 dB(A). Average noise exposure level (LAVG) during measurement period for the respondents was 95.2±3.1 dB(A) for 3Sqn, 116.0±4.4 dB(A) for 15Sqn and 121.4±4.7 dB(A) for 18Sqn. Overall prevalence of NIHL among RMAF aircraft technicians was 24.2%. The significant predictor for NIHL were involvement in loud sound leisure activity (aOR=2.491, 95%CI=1.113-5.574, $P<0.05$), and those who ever experienced tinnitus (aOR=4.335, 95%CI=1.169-5.662, $P<0.05$).

Conclusion: NIHL was prevalent among military aircraft technicians. Therefore, control of noise hazards and good practice towards noise should be implemented in RMAF workplace.

Keywords: Noise induced hearing loss, Air Force, aircraft technician, sound pressure level

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1.0 Introduction

Noise-induced hearing loss (NIHL) is a predictable and preventable disease. It can be caused by an acute exposure to an intense impulse of sound or by a continuous steady-state long-term exposure with sound pressure levels higher than 75–85 dB (Jenica S. Y & De-Yun W. 2015). Worldwide, about 360 million people comprising more than five percent of the world population have disabling hearing loss (328 mil adults, 32 mil children) (WHO, 2013). An estimated of $242 million is spent annually on worker's compensation for hearing loss disability (NIOSH, 2012). According to the National Institute of Occupational Safety and Health (NIOSH), NIHL is on the top list in the category of diseases caused by physical agents, and further has been classified by the World Health Organisation (WHO) as the greatest compensable occupational hazard (Mahboubi, H. et al, 2013).

In many countries, excessive noise becomes the biggest occupational hazard. Hearing impairment continues to be the most prevalent disability in Western societies. According to National Institute of Occupational Safety and Health (NIOSH) USA, occupational hearing loss is the most common work-related illness in the United States. Approximately 22 million U.S. workers exposed to hazardous noise levels at work, and an additional 9 million exposed to ototoxic chemicals. An estimated $242 million is spent annually on worker's compensation for hearing loss disability. It is estimated that about 7% of the total population in the US are at risk for hearing loss from noise (NIOSH, 2012). In Germany, 4−5 million people (12−15% of the workforce) are exposed to noise levels defined as hazardous (WHO, 2004). For the western pacific region country like Japan, there were numerous studies on noise control or hearing conservation at noisy workplaces have been done. From these studies they came out with several administrative guidelines and legislation acts to prevent NIHL among their workers who are exposed to loud working environment (WHO-Geneva, 2004).

Noise is one of the environmental and occupational hazards listed in the Factory and Machinery Act 1967 in our country. Cases of NIHL investigated by the Department of Occupational Safety and Health (DOSH) had increased from 120 cases in 2007 to 427 cases in 2009 (Filza Ismail, A. et al, 2013). According to Social Security Organization (SOCSO), a total of 86 NIHL cases were compensated in 2008 and the statistic increased to 237 in 2012 (Azimah C.A., 2014). In 2012, there were 956 cases of NIHL reported and made NIHL became the top occupational disease in Malaysia (DOSH, 2013). Therefore, NIHL is a significant public health problem for the general population and the workforce.

In military, hearing plays a vital role in the total performance of a soldier especially in military communication and commands comprehension. Presence of tinnitus and hearing loss can significantly impairs a soldier's ability to hear important acoustic cues or communication signals from the unit or the enemy. Many researches showed that the prevalence of hearing and tinnitus among military population are greater than the general population (Amy, 2009; Collee A. et al., 2011; Yankaskas, 2013; Pfannenstiel, 2014). Collee et al., 2011 had showed the prevalence of hearing loss in Belgian military population was as high as 55.8%, meanwhile Rovig, et al., 2004 proved a prevalence of hearing impairment among aircraft carrier flight deck personnel in USAF was 27.1%. Therefore this study was done in concern of excessive noise exposure among the Royal Malaysian Air Force (RMAF) aircraft technicians work with aircraft maintenance.

Aircraft noise exposure is considered to be one of the major factors causing permanent hearing loss among military crew members. Nowadays, high performance aircrafts owned by RMAF are more powerful, more efficient, and undoubtedly produce higher noise levels resulting in NIHL among the pilots and aircrews. Aircrews and ground crews in RMAF are required to perform many flight duties and they have to spend a lot of times in the aircrafts facing with all kinds of aircraft hazards including excessive aircraft noise. They are exposed to noise at work and are at risk of developing hearing loss in excess of that which naturally results from aging. Therefore, this study was intended to assess the prevalence of NIHL among Royal Malaysian Air Force aircraft technicians in Butterworth Air Base according to the types of aircraft maintained and to look at the predictors for NIHL.

2.0 Materials and Methods

A cross sectional study was conducted in Butterworth Air Base, Penang. The study population in this research was all RMAF personnel in Butterworth Air Base. A list of names of all aircraft technicians were obtained from the Squadron Administrative Unit based on their respective Squadron. A simple random sampling was applied to select the study subjects. The sample size estimation was calculated using two proportion sample size formulation by Lemeshow, Hosmer, Klar, and Lwangsa, 1990 with alpha level of 0.05%, power of 80% and a total of 328 respondents were required and selected for this study. RMAF aircraft technicians who are working in Butterwoth Air Base at the time of data collection were included while those who are on leave, attended long courses, suffering from medical hearing problems and who has psychiatric illness diagnosed by medical officer/specialist were excluded from the study.

2.1 Instruments Used

Instruments used in this study were a set of questionnaire on respondent's data; a sound level meter (SLM) to measure the sound level pressure emitted from the various aircrafts engines in the squadrons' hangars; a personal dosimeter for noise dose exposures measurement; and a pure tone audiometry located at the base's 816 Rumah Sakit Angkatan Tentera (RSAT) to measure hearing threshold for all respondents.

2.1.1 Questionnaires

The questionnaire of this study consists of 27 questions adapted from two different studies. It was a self-administered instrument, standardized, pre-tested, validated and structured questionnaire. The questionnaire comprise of five sections namely; section A, B, C, D and E. Section A covered on questions of socio-demographic characteristics for the respondents, section B on occupational characteristics, section C on their medical history and section D covered the respondent's life style behaviours. Meanwhile, section E consisted of questions on their knowledge, attitude and practice regarding occupational noise and NIHL at workplace.

The questionnaire was checked by Occupational Health Specialist for the content validity. The pilot test was conducted among 33 aircraft technicians in 11 squadron. Correction and modification of the questionnaire was done according to their comments. Reliability analysis

was performed to assess the reliability of the questions by looking at the Cronbach's alpa values. Cronbach's alpa was used to evaluate the internal consistency of the questionnaire. For this study, Cronbach's alpa value of more than 0.7 is generally considered as high internal consistency. The Cronbach's alpa value for the pilot study of this research ranged from 0.78 to 0.86.

2.1.2 Personal Noise Dosimeter

A dose badge personal noise dosimeter model CR:110A/BLK was used to measure noise dose exposure of the aircraft technicians. Unlike SLM which is more bulky and mostly being used to measure a static noise source, personal noise dosimeter was used to measure noise exposure on an individual while the technician was working and moving from one location to another location around the aircraft. In other word, it measured the sound level that actually received by the workers. The small size and light weight make it suitable and comfortable for the technicians to wear and carry it during the sound level assessment.

2.1.3 Pure Tone Audiometry (PTA)

Audiometric testing was performed individually in a sound-proof booth with an Inter-acoustics Clinical Audiometer (Model AC30). Prior to the testing, all respondents were checked their ears for any ear abnormalities such as perforated ear drum, any signs of acute or chronic otitis, impacted ear wax and others by the researcher and 816 Armed Force Sick Quarters' or Rumah Sakit Angkatan Tentera (RSAT) medical officer. All of them were reminded to be free from occupational noise exposure of the last work shift for at least 16 hours meanwhile 6 to 8 hours from leisure activity involving loud noise at night (Noweir and Zytoon, 2013). The audiometric testing was performed at 8 am every working days. Hearing thresholds (with a decrement of 10 dB and an increment of 5 dB; starting at 50 dB) were measured by a trained military medical personnel prior to the study at each of seven pure tone frequencies (500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz), for both ears. The test started with the respondent's better ear. Otherwise, the right ear became the default starting ear. For all respondents the test started at the frequency 1000 Hz. Then the threshold was tested at 500 Hz, followed by a retest at 1000 Hz. If the first and second thresholds at 1000 Hz agree within 5 dB, testing continued for 2000, 3000, 4000,6000, and 8000 Hz (Frank, 2001).

2.2 Data Analysis

Data was analyzed using IBM Statistical Package for Social Science (SPSS) version 21.0 comprising descriptive, bivariate and multivariate analysis. Descriptive statistics was used to describe characteristics of the respondents. Bivariate analysis of Chi-Square (χ^2) was used to measure associations between two categorical variables and recorded as frequency (n) and percentages (%). The final model of predictor was determined using Binary Logistic Regression and P value of less than 0.05 were considered significant in this study. Ethical approval from Ethical Committee for Research involving Human Subjects of University Putra Malaysia (JKEUPM) and Institute of Aviation Medicine were obtained. Respondent's concern were taken prior to data collection.

3.0 Result

3.1 Characteristic of Respondents

There were total of 263 respondents completed Pure Tone Audiometry (PTA) test from a total of 320 eligible respondents, making the response rate of 80.2%. Normality test was conducted and revealed normal distribution for all the continuous variables. The mean age of the respondents was 31.98 ± 4.81 year old, ranged from 22 to 51 year old. Majority of the respondents, 314 (51.0%) were aged between 31 to 40 year old. More than three quarter of the respondents, 232 (88.2%) were male and 31 (11.8%) of them were female technicians. 232 (88.2%) Malay respondents were contributed for the research whereas only 31 (11.8%) of them were non-Malay. Out of 31 non-Malay respondents, six were Chinese, nine were Indians and 16 were other races from Sabah and Sarawak indigenous people such as Kadazan, Bidayuh, Iban and Melanau. From the total respondents, 218 (82.9%) respondents were married, 40 (15.2%) were single and five (1.9%) of them were divorced/widowed. For educational level of the respondents, there were 43 (16.3%) respondents had higher educational level which at least of holding diploma/STPM and above. Majority of them, 216 (82.1%) were having SPM qualification (Table 1).

Table 1: Socio-demographic Characteristics of the Respondents According to Group

Socio-demographic characteristic	Frequency (%) (n=263)			
	3 Squadron	15 Squadron	18 Squadron	Total
Age				
≤ 30 year old	43(47.8)	39(45.3)	33(37.9)	115(43.7)
31 to 40 year old	38(42.2)	45(52.3)	51(58.6)	134(51.0)
> 40 year old	9(10.0)	2(2.4)	3(3.5)	14(5.3)
Gender				
Male	87(96.7)	69(80.2)	76(87.4)	232(88.2)
Female	3 (3.3)	17(19.8)	11(12.6)	31(11.8)
Ethnicity				
Malay	80(88.9)	77(89.5)	75(86.2)	232(88.2)
Non Malay	10(11.1)	9(10.5)	12(13.8)	31(11.8)
Marital status				
Single/Divorced/Widowed	22(24.4)	7(8.1)	16(18.4)	45(17.1)
Married	68(75.6)	79(91.9)	71(81.6)	218(82.9)
Educational level				
SPM and below	73(81.1)	72(83.7)	75(86.2)	220(83.7)
STPM/Diploma and higher	17(18.9)	14(16.3)	12(13.8)	43(16.3)

3.2 Noise Level Exposure among Aircraft Technicians

Study showed that the time weighted average for 8 hours (TWA) for respondents in 3 Sqn was 93.2 ± 2.0 dB(A), 15 Sqn was 112.0 ± 5.2 dB(A) and 18 Sqn was 118.1 ± 3.6 dB(A), average noise exposure level (LAVG) during measurement period for the respondents was 95.2 ± 3.1 dB(A) for 3Sqn, 116.0 ± 4.4 dB(A) for 15 Sqn and 121.4 ± 4.7 dB(A) for 18 Sqn. The peak sound level for 3, 15 and 18 Sqn was 96.3 ± 3.2 dB(A), 118.1 ± 3.6 dB(A) and 122.3 ± 4.4 dB(A). Meanwhile for the dose percentage result for 3, 15 and 18 Sqn was 145.2 ± 35.5%, 256.5 ± 23.5% and 308.5 ± 60.2% respectively as per Table 2. From 24 of

respondents, all of them exposed to noise level more than 90 dB(A) during the measurement period meaning that all of them was exposed to more than permissible exposure level for continuous noise set by DOSH.

Table 2: Noise Level Exposure among Aircraft Technicians

Variable	Mean ± S.D		
	3 Squadron	15 Squadron	18 Squadron
Time weighted average (TWA)	93.2 ± 2.0 dB(A)	112.0 ± 5.2 dB(A)	118.1 ± 3.6 dB(A)
Average noise level exposure (LAVG)	95.2 ± 3.1 dB(A)	116.0 ± 4.4 dB(A)	121.4 ± 4.7 dB(A)
Peak level	96.3 ± 3.2 dB(A)	118.1 ± 3.6 dB(A)	122.3 ± 4.5 dB(A)
Dose	145.2 ± 35.5%	256.5 ± 23.5%	308.5 ± 60.2%

n=24

3.3 Prevalence of Hearing Loss, Hearing Impairment and NIHL of Respondents

Among 263 respondents in this study, 119 (45.2%) of them recognized to have hearing loss with hearing threshold ≥ 25 dB(A) at any frequency, sixty four (24.3%) documented to have NIHL and 20 (7.6%) of respondents were having hearing impairment. The highest prevalence of NIHL and hearing impairment was recorded among the respondents from 18 Sqn which were 26 (29.9%) and 7 (8.0%) respondents. Additionally, among 20 respondents who were detected to have hearing impairment, 11 (55%) were developed unilateral hearing impairment (seven of them affected on the left ear and four on the right ear) and nine (45%) were having bilateral hearing impairment (Table 3).

Table 3: Prevalence of NIHL and Hearing Impairment According to Each Squadron

NIHL	Frequency (%) (n=263)			
	3 Sqn	15 Sqn	18 Sqn	Total
NIHL				
Yes	16(17.8)	22(25.6)	26(29.9)	64(24.3)
No	74(82.2)	64(74.4)	61(70.1)	199(75.7)
Hearing Impairment				
Yes	7(7.8)	6(7.0)	7(8.0)	20(7.6)
No	83(92.2)	80(93.0)	80(92.0)	243(92.4)
Hearing affected				
Normal	243(92.4)			
Left HI	7(2.7)			
Right HI	4(1.5)			
Bilateral	9(3.4)			

3.4 Predictors of NIHL for Aircraft Technicians in Butterworth Air Base

Binary Logistic Regression in Table 4 showed only two factors were considered as being significant predictors for NIHL. Both respondents who involved in loud sound leisure activity (aOR=2.491, 95%CI=1.113-5.574, P<0.05), and those who ever experienced tinnitus in their daily life (aOR=4.335, 95% CI=1.169-5.662, P<0.05), especially after finished working at squadron aircraft hangar become the predictors for NIHL in this study. The adjusted odds ratio for involvement in loud sound leisure activity was 2.491 meaning that there were about 2.5 times higher risk for those who exposed to loud noise from leisure activity to develop NIHL. Respondents who always experienced tinnitus will have about 4 times more risk to develop NIHL compared to those who never experience tinnitus. Meanwhile, those who complained of having tinnitus for sometimes in their life will develop NIHL about 2 times higher risk compared to those who not experience it. All the odds values here were considered as significant since 1 is not included in the 95% confidence interval values for each mentioned variables. According to Nagelkerke R Square value, only 42.6% of this model was explained by the included variables in Binary Logistic Regression analysis. This results showed that there are more than 50% other potential risk factors that were not included in this study such as genetic components, environmental exposures and others.

Table 4: Predictors of NIHL for Aircraft Technicians in Butterworth Air Base

Variables	**β**	**S.E**	**Adjusted Odd Ratio**	**95% CI for odd ratio**	**p value**
Age	0.093	0.077	1.098	0.945 - 1.276	0.223
Duration of service	0.130	0.086	1.139	0.962 – 1.347	0.129
Smoking duration	0.024	0.021	1.025	0.984 - 1.067	0.240
Marital status					
Single/widowed	1	1	1	1	1
Married	0.412	0.862	1.150	0.279 - 8.179	0.632
Income (RM)					
Less than 3000	1	1	1	1	1
3001 to 4000	0.450	0.893	1.569	0.430 - 5.718	0.495
More than 4000	1.643	0.987	1.547	0.410 - 5.837	0.519
Leisure activity involving loud noise					
Involved	0.912	0.411	2.491	1.113 – 5.574	**0.026***
Not involved	1	1	1	1	1
Tinnitus					
Yes, always	1.094	0.348	4.335	1.169 - 5.662	**0.020***
Sometimes	1.436	0.438	2.202	1.783 – 6.707	**0.01***
No	1	1	1	1	1
Noticed hearing problem					
Yes	0.451	0.320	1.569	0.838 - 1.938	0.159
No	1	1	1	1	1
Feedback from friend/ relative					

Yes	0.291	0.380	1.338	0.635 – 2.812	0.444
No	1	1	1	1	1
Conversation problem in loud environment					
Yes	0.579	0.562	1.784	0.694 – 4.232	0.330
Sometimes	0.576	0.480	1.780	0.592 – 5.370	0.233
No	1	1	1	1	1
Constant	-9.524	3.057	0.002		**0.001***

*Significant value at $p < 0.05$
R^2 Nagelkerke = 0.426

4.0 Discussion

Nowadays, both hearing impairment and NIHL are common illnesses and becoming important source of disability among workers and often caused by occupational noise exposure. NIHL also turn out to be a significant public health priority as well because, as populations live longer and industrialization spreads, NIHL will add substantially to the global burden of disability. NIHL is preventable and under the Occupational Safety and Health Act (OSHA) 1994, employers, employees and self-employed persons have a duty of care towards their own safety and health, and to that of others at their workplace. Malaysia is a developing, upper-middle income country with a multi-ethnic population. Thus, occupational noise and urbanisation, becomes an increasing risk factors for hearing impairment. According to DOSH under Factories and Machinery (Noise Exposure) Regulations 1989, hearing impairment is defined as an arithmetic average of the permanent hearing threshold level of a worker at 500, 1000, 2000, and 3000 Hz which is shifted by ≥25 dB in one or both ears). Meanwhile, NIHL is defined as thresholds ≥25 dB at 3,000, 4,000, or 6,000 Hz, with recovery at 8,000 Hz at both ears (Krishnamurti, 2009).

For this study, all measurement for noise level was more than 90 dB (A) which indicates the seriousness of the problem of noise exposure of the Air Force aircraft technicians in general. All the operations and tasks involved while maintaining and servicing RMAF aircrafts in particular aircraft maintenance hangars in all flying squadrons produces noise of levels higher than the permissible limit exposure set by DOSH. Most RMAF aircraft maintenance and repairing services are made in the respective flying squadron aircraft hangers and these operations involve aircraft engine testing which produces noise of levels higher than the permissible limit exposure set by DOSH. Analysis on the auditory effects among respondents in Butterworth Air Base alone showed the prevalence of hearing impairment was 7.6% and NIHL was 24.3%. The prevalence of NIHL in this study is similar to a study on population of aircraft carrier flight deck personnel by Rovig et al. 2004. The study reported that 27.4% of the respondents developed NIHL.

In terms of sound level emitted from aircrafts measurements in this study, it showed that the sound level for all aircrafts surpassed the civilian or commercial aircrafts. It was based on a study by Noweir and Zytoon, 2013 which revealed that sound emitted from civilian commercial aircrafts were in range of 89.3 ± 1.5 dB(A) to 93.4 ± 1.9 dB(A). However, the

sound level emitted from helicopter Nuri was almost similar compared to other studies done on military aircrafts. Studies showed the average noise level in service helicopters was found to be 97 dBA for 'Gazelle' , 99.8 dBA for the 'Scout' , 99.9 dBA for the 'Puma' and 100 dBA for the 'Lynx' (Owen J.P., 1995). Meanwhile, in fighter planes, the noise level ranged from 97 to 104 dBA, in jet trainers the noise level was at 100 to 106 dBA and in transporter aircrafts, the noise level was found to be between 88 to 101 dBA (Kuronen, P. et al, 2004).

From the findings of this study, there are some improvements that can be done based on the hierarchy of noise control to ensure the prevalence of NIHL among aircraft technicians in all RMAF operational air bases will not increase in the future. This study was limited to only studying certain types of aircrafts as a factor towards hearing loss among the aircraft technicians. It was not include the RMAF aircraft technicians since there is no transport aircraft squadron in Butterworth Air Base. There were only selected socio-demographic and occupational factors affecting hearing loss among the aircraft technicians were chosen as contributors to hearing loss. There are numerous other factors which are equally important such as environmental noise exposure, habitual and recreational factors in details, exposure to chemicals at workplace which might lead to hearing loss, head injury secondary to accidents, alcohol beverages, respondents who are already having hearing problem prior joining the service, other military activities involving loud noise such as firearms handling and other variables.

5.0 Conclusion and recommendation

This study was the first to characterize the prevalence of NIHL in Royal Malaysian Air Force (RMAF) population. However, it should be interpreted with careful since the study design does not provide us to know the temporal causative factors in the study outcomes. The result showed NIHL prevalent among military aircraft technician. Therefore, it may be used as an indicator to set appropriate measures for hearing protection and policy making among RMAF aircraft technicians. Risk factors identified in this study can be targeted through various interventions in the future such as educational, preventive, and screening programs based on the hierarchy of noise control at workplace.

Recommendations for future research would be a more detailed study using a cohort study for a longer period of time. Interventional study design using educational module combining with social cognitive model like Health Belief Model (HBM) can be conducted which could contribute to in-depth individual health behaviour and at the same time will increase their knowledge towards the importance of NIHL.

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Declaration

Author(s) declare that no competing interests.

Authors contribution (if more than one author)

Author 1: Writing the draft for manuscript, data collection and analysis.

Author 2: Revised manuscript critically for important intellectual content.

Author 3: Review, editing manuscript for publication.

Author 4: Review on the technical and operational aspect.

Author 5: Data collection and language checking.

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