Environmental Noise and the Association with Occupational Stress among Palm Oil Mill Workers

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ABSTRACT: In palm oil mills the environmental sound level, resulting from operating machineries, is usually exceeding the action level of noise (85dB(A)). Whereas the excessive noise can develop chronic job stress, thus this study aims to determine the relationship between personal noise exposure and occupational stress among palm oil mill workers. A cross sectional study was done among 173 workers at five selected mills namely in Perak, Selangor and Negeri Sembilan. Environmental noise and personal noise exposure measured using Sound Level Meter (Model: Lutron SL-4112) and Dosimeter (Model: wireless110A) respectively. Alpha-amylase activity was used to determine the non-auditory effects of noise through determining the stress level. Results showed that, 100% of the workers among exposed group (PNE≥85 dB (A)) experiencing stress condition while 43% of non-exposed group (PNE<85dB (A)) experiencing stress condition. Statistically alpha amylase activity in stimulated condition among exposed group was significantly higher than non-exposed group (t-value=-3.983, p-value=0.000). As the conclusion, there is a significant relationship between alpha amylase activity and personal noise exposure among palm oil mill workers. (rs=0.725, p-value=0.000)

Keywords: Noise exposure, alpha amylase activity, Job stress, Palm oil mill workers

1. INTRODUCTION

Malaysia is the world's second largest producer and exporter of palm oil has an important role to play in fulfilling the growing global needs for oils and fats sustainability. About 429 palm oil mills are operating all over Malaysia with the total capacity of 101, 958, 40 tonnes per year, produce about 47% of the world's supply of palm oil. This industry employed an estimated 491,000 workers (Official portal Malaysian palm oil board, 2014). However a well-managing, proper monitoring and control existing stressors gradually resulted in increase productivity and efficiency of this industry. Noise as an ambient stressor cause a series of non-auditory effects which cannot be overlooked. The environmental noise resulted from operating machineries usually exceeded the action level of 85 dB (A) (Department of Occupational Safety and Health (DOSH), 2013) and as one of the most important environmental stressors in palm oil mills is always considered as a key factor in creation of a series of complaints and develop job stress as a chronic disorder among palm oil mill workers. Due to importance of palm oil industry in Malaysia, any hazard that poses a threat to the health of organization cannot be underestimated. A significantly high number of researches had investigated on the potential of noise-induced hearing loss in terms of auditory effects [1], [2], [3], [4], [5], [6]. However, there is a lake of attention is being paid to the non-auditory effects of noise. The present study examined a combination of psychological and physiological effects induce occupational stress among palm oil mill workers and aimed to determine the relationship between personal noise exposure and occupational stress level.

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Non-Auditory Effects of Noise

Noise induced variety of non-auditory adverse. The meta-analysis of studies from 1950 to 2008 conducted by Tomeib [7] shows a statistically significant increase of blood pressure and heart rate in high exposed workers compared to low exposed workers. The analysis of global alterations of lung function parameters has been undertaken by Cardoso [8] among 28 women working in cotton-mill and the study suggests small airways aggression by noise. The study by Chen [9] among 31 dentists indicated that nearly all participants (96.8%) were annoyed by all sources of dental noise. Furthermore Frei [10] conducted a questionnaire base study among 119 subjects exposed to road traffic noise and the results indicated that sleep quality was strongly related to noise annoyance. Much research provided a systematic overview of the evidences about the health effects of excessive noise. The most recent evidence suggested a link with mental health issues including negative emotional responses, anger, depression, hyperactivity, and social behavior [11]. In 2009, Stansfeld [12] conducted a cross-sectional study assessing 2844 pupils, indicated that high aircraft noise exposure exacerbates hyperactivity symptoms in children. Endocrine

response is proved to be associated with sympathetic nervous system activity, which reflects psychological stress [13].

Endocrine responses, Alpha amylase activity

Endocrine responses is one of the non-auditory effects of noise exposure and identified as multiple psychophysiological reaction involved in perceiving, reacting to and recovering from threat and challenge The endocrine system responses the nervous system to form the control systems of the body to cope with stressors" [14].Salivary α -Amylase (sAA) is one of the major salivary proteins and considered as a biological indicator for stress reactions after neurotransmitter stimulation [15]. Recent studies have found that sAA has been proposed to indicate stress-reactive body changes in psychophysiological research and clinical practice [16].

2. MATERIALS AND METHODS

This comparative cross-sectional study was conducted since July 2013 until March 2014 at seven selected section of five palm oil mills (Loading Ramp, Sterilizing, Pressing, Nut Plant, Clarification, Boiler Room, Workshop) located in different states of Malaysia (Figure 1).

Figure 1**: A) Loading Ramp, B) Sterilizing, C) Pressing, D) Nut Plant, E) Clarification, F) Boiler Room, G,H) Workshop**

The sample size was calculated using the following formula (Lu Ann Aday, 206).

$$n = \frac{Z_{1-\alpha 2}\sqrt{2\overline{P}(1-\overline{P})} + Z_{1-\beta 2}\sqrt{P1(1-P1)+P2(1-P2)}}{(P1-P2)}$$

Where: n: Sample size
P = (P1+P2)/2
P1 = estimated proportion (larger)
P2 = estimated proportion (smaller)
Z: confidence interval =1.96 (1-ά=1-0.05=0.95)

The respondents were selected based on inclusive(Male workers, Malaysian, Those work in selected sections) and exclusive criteria (Diagnosed with cushing disease, cardio vascular disease, psychiatric disorder, changing in sleeping pattern, below 18 and more than 65 years old, Working less than one year, Addicted to drugs). The estimated total sample size in this study was 118 respondents but due to achieving more accurate results the sample size increased to 173 samples. The respondents were required to answer a set of questionnaire included questions on socio demographic and job characteristics. These helped the researcher to access the risk factors that may associate with occupational stress level. The respondents who could fulfill the inclusive and exclusive criteria in the first data set, were enrolled the study as the sampling unit.

Environmental sound level was identified at each section using Lutron SL-4112 Sound Level Meter while the SLM was calibrated in advance using the sound-level calibrator (TES-1356, TES Electronic Corp., Taipei, Taiwan) based on SOP of the equipment. The measurements were performed based on ISO 9612 standard method while the machineries were operating regardless the interference of other sections sound. Results were used to classify the noisy (L_{eq} (dBA) ≥85) and standard (L_{eq} (dBA) <85) working area.

Figure 2: Lutron SL-4112 Sound Level Meter and Data Collection approach

The wireless110A personal noise dosimeter was used for personal noise exposure measurement upon each participant in order to classify the workers in two exposed and non -exposed groups. Personal noise exposure (8-hour TWA) with the range of 45–120 dB (A) used to measure all subjects' noise exposure at least for 2 hours. The dosebadge was calibrated using the acoustic calibrator of the reader unit. The dosibadge was clipped on worker's shoulder close to the ear and was frequently checked to ensure correct operating.

Figure 3: wireless110A Personal Noise Dosimeter and Data Collection approach

Salivary Alpha amylase (sAA) is considered as the bio marker indicator to evaluate the occupational stress level in this study. The instruments needed for saliva sample collection were: Salimetrics Oral Swab (SOS), Salimetrics Swab Storage Tube (SST) and salivary alpha-amylase assay kit. Two-stage sampling was applied upon each one of the respondents. The first sampling is considered as the resting condition, before entering to the

work. The second stage sampling as the stimulated condition, was collected after 8 hours, approximately at the end of working shift. The data collection approaches were according to the Salimetric instruction. The workers were required to circulate and chew the SOS for 1-2 minutes to motivate the salivary glands (1.0 g/mL saliva sample) (Harmon *et al*. (2008). The storage tubes were stored in -20°c in to the refrigerator so as the data collection completed. Analyzing the samples was according to manufacturer's manual salivary α-amylase assay kit.

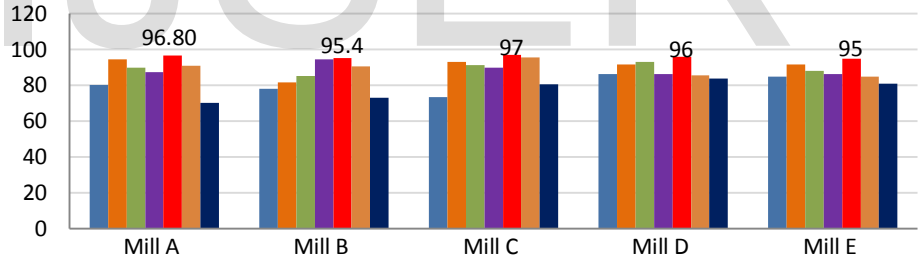
Figure 4: A) Salimetrics Oral Swab (SOS), B) Salimetrics Swab Storage Tube (SST), C) Salivary alpha-amylase assay kit.

3. RESULTS

The collected data was analyzed using Statistical Package for Social Science version 21with the p value determination on $p<0.005$.

Environmental sound level

Figure 5 shows that among all five mills only in workshop the environmental sound (ESL) level did not exceeded the action level (85dB (A)) while the only work section that the ESL exceeded the permitted level of noise (90dB (A)), was nut plant. According to Table 1, the lowest average of ESL was belong to workshop (80.04±4.27dB (A)) while the average of ESL for Nut plant is the highest one (94.80±2.49 dB (A)) in combination of five mills. Thus the results indicated that workshop is the quietest and noiseless working area while nut plant is considered as the noisiest section

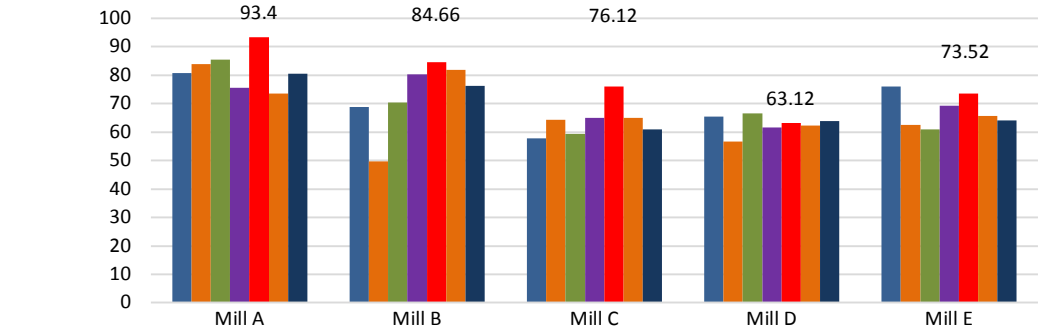


	Mill A	Mill B	Mill C	Mill D	Mill E
Loading Ramp	80.2	78.2	73.5	86.4	85
sterilizer	94.7	81.6	93.2	91.9	91.9
oil room	89.9	85.2	91.3	93.2	88
press	87.5	94.5	90	86.4	86.4
nut plant	96.8	95.4	97	96	95
boiler	91	90.8	95.6	85.6	84.9
workshop	70.2	73.2	80.5	83.7	81

Figure 5: The environmental sound level (dB(A)) at each mill (Leq A)

Personal noise exposure

Figure 6 and Table 1 show the average of personal noise exposure (PNE) in each mill individually and in combination of five mills respectively. According to the results only in nut plant of mill A the average of PNE is exceeded the permissible level of noise (93.4 dB (A)). However in all the sections of 5 mills the average of PNE have not exceeded even the action level (85 dB (A)). The average of PNE level for each section in combination of five mills is displayed in table 2. According to the results nut plant has the highest level of PNE (74.89± 12.91dB (A)) while the lowest value of PNE has been recorded among sterilizer workers (66.07±14.17 dB (A)).



	Mill A	Mill B	Mill C	Mill D	Mill E
Loading Ramp	80.8	68.8	57.72	65.45	75.97
Sterilizer	83.96	49.7	64.25	56.75	62.47
Oil Room	85.4	70.47	59.3	66.53	60.96
Press	75.53	80.3	64.95	61.55	69.23
Nut Plant	93.4	84.66	76.12	63.12	73.52
Boiler	73.48	82	64.93	62.28	65.66
workshop	80.45	76.31	60.92	64	64.07

Figure 6: Personal noise exposure level (dB (A)) at each mill (TWA)

Table 1: average of environmental sound and personal noise exposure level at each section in five mills

Variable	Environmental sound level (L_{eq} (dBA))				Personal noise exposure (TWA)		
work section	Mean	±SD	Min	Max	Mean±SD	Min	Max
Loading Ramp	81.04	±4.26	73.50	86.40	72.07±10.84	50.00	89.40
Sterilization	91.04	±4.63	81.60	94.70	66.07±14.17	49.70	93.40
Oil Room	89.25	±3.25	85.20	93.20	67.87±13.50	41.00	85.40
Press	89.51	±3.36	86.40	94.50	69.48±15.94	45.60	88.70
Nut Plant	94.80	±2.49	87.00	97.00	74.89± 12.91	48.00	93.40
Boiler Room	88.65	±4.14	84.90	95.60	67.87±10.79	43.80	84.20
Workshop	80.04	±4.27	70.20	83.70	69.28±15.53	50.00	89.40

Alpha amylase activity

To evaluate the difference of salivary α-amylase activity variation between resting and stimulated condition, the results are compared between two categories (Exposed and non-exposed groups). In non-exposed group (PNE<85dB (A)), the average of α -amylase activity was 2.70 ± 1.51 U/ml and it has been increased to 5.22 ± 2.07 U/ml in stimulated situation. Also in exposed group (PNE>85dB (A)), the average of α -amylase activity was

2.98 ± 1.81 U/ml. In this case also the value increased to 6.94 ± 1.96 U/ml in stimulated situation. According to the results shown in Table 3, there was no significant difference between the mean scores of resting α-amylase activity between the exposed and non-expose groups (t =- -0.865(171), p =0.388). However, the average of salivary α-amylase activity in stimulated situation is significantly higher among exposed compared to non-exposed group (t =-3.983(171), p <0.001).

Table 2: The difference of salivary α-amylase activity variation (U/ml) between resting and stimulated condition in exposed and non-exposed group

Condition	α-amylase activity(U/ml) Mean±SD					
	N	Non-exposed	N	exposed	t value	p value
Resting	146	2.70±1.51	27	2.98±1.81	-0.865 (171)	0.388
Stimulated	146	5.22±2.07	27	6.94±1.96	-3.983 (171)	0.000

Relationship between stress level and Alpha amylase activity

The results show that statistically a significant strong correlation is observed between PNE level (TWA) and variation of alpha-amylase activity (r_s =0.725, p<0.05),

Table 3: Relationship between stress indicators and personal noise exposure

Indicators	Personal noise exposure (TWA)	
	r_s	p value
Variation of alpha-amylase activity (U/ml)	0.725**	0.00

Association between stress levels (Alpha amylase activity) and selected risk factors

The results displayed in two tables (Tables 4 and 5) show the association of socio-demographic factors and occupational characteristics with stress level by using chi-square test. According to results among eleven selected risk factors only personal noise exposure level has the significant association with stress level (χ^2 (df) = 36.185(1), p <0.005)

Table 4: The association between stress levels (Alpha-amylase activity) and selected risk factors (Socio-demographic factors)

Variable	Total N (%)	Alpha-amylase Level Freq (%)		Mean±SD	χ^2 (df)	p value
		low	high			
Age						
20-29	58 (33.7)	31(53.4)	27(46.6)	38.3±11.38	4.765	0.092
30-39	25 (14.5)	7 (26.9)	18 (69.2)		(2)	
≥40	89 (51.7)	44 (49.4)	45 (50.6)			
Marital status						
Single	47 (27.5)	24 (51.1)	23(48.9)		0.251	0.732
Married	124 (72.5)	58 (46.8)	66 (53.2)		(1)	
Education						
Non formal education	6 (3.5)	1 (16.7)	5(83.3)		7.881	0.049
Primary	22 (12.9)	7 (31.8)	15(68.2)		(3)	
Secondary	132 (77.2)	70(53.0)	62 (47.0)			
Diploma	11 (6.4)	3 (27.3)	8 (72.7)			
Number of household						
0-5	112 (66.30)	50(45.0)	61(55.0)	4.72 ±2.05	0.141	0.707
>5	57 (33.70)	31(54.4)	26(45.6)		(1)	
BMI						
< 18.5 Under weight	12 (7.1)	5(41.7)	7(58.3)	24.91 ±4.5	3.563	0.313
18.5-22.9 Normal	53 (31.5)	20(37.7)	33(62.3)		(3)	
23-27.4 Pre obesity	60 (35.7)	33(55.0)	27(45.0)			
>27.4 Obesity	43 (25.6)	21 (48.8)	22(51.2)			

Table 5: The association between stress levels (Alpha-amylase activity) and selected risk factors (Occupational characteristic factors)

Variable	Total N (%)	Alpha-amylase Level Freq (%)		Mean±SD	χ^2 (df)	p value
		Low	High			
Noise exposure						
TWA<85 dB(A)	145(84.3)	82(56.6)	63(43.4)	69.55±13.43	29.181	0.000
TWA≥85 dB(A)	27(15.7)	0	27(100)		(1)	
Work shift						
Normal	69(40.1)	37(52.9)	32(45.7)		1.635	0.216
Night shift	103(59.9)	45(43.7)	58(56.3)		(1)	
PPE usage						
Yes	112(65.1)	62 (54.9)	50(44.2)		7.597	0.007
No	60 (34.9)	20(33.3)	40(66.7)		(1)	
Work experience						
<2 Years	35(20.3)	19(52.8)	16(44.4)	11.24 ±9.6	1.069	0.586
2-7 Years	49(28.5)	21(42.9)	28(57.1)		(2)	
>7 Years	88(51.2)	42(47.7)	46(52.3)			
Working hours/ Day						
≤8 Hours	86(50.0)	41(47.7)	45(52.3)	9.60 ±1.91	0.000	1.000
>8 Hours	86(50.0)	41(47.7)	45(52.3)		(1)	
Salary (RM)						
<1000	66(39.3)	33(50.0)	33(50.0)	1317±466	0.247	0.638
≥1000	102(60.7)	47(46.1)	55(53.9)			

4. DISCUSSION

Environmental sound level

According to the factory and machinery (noise exposure) Regulation 1989 requirement to conduct the area noise monitoring, during a typical working day an Environmental Sound Level (ESL) measurement was taken at seven sections individually. According to the results displayed in figure 5 and table 1, Nut plant section has the highest level of environmental sound (94.80±2.49 dB (A)). It would be due to the function of the cracker that was working in this section. Cracker use stone tool for nut cracking consists of trundling the hard-shelled nut inside a horizontal cylinder and cracking the shells by pounding it with the stones to get to the kernel. The result of this study is comparable with the findings by Uswir [17]. However the selected sections in two studies were different but in some common points such as nut plant the results support each other and in some point such as Boiler section, her results indicated higher ESL than the results obtained by current study. It could be due to the size, capacity and type of the boiler used in different mills. The results from figure 5 show that the average of environmental noise in all five mills exceeded the action level of noise (85dB (A)). Mill A (85.53±8.05 dB (A)), had the lowest average of ESL and Mill C (89.15±8.02 dB (A)) had the highest environmental sound level within five mills The circumscription of the area and capacity of machineries the number of the machineries, different types of sterilizer system, could easily explain the different average of environmental sound level in Mill A (85.53±8.05 dB (A)) and Mill C (89.15±8.02 dB (A)).

Personal noise exposure

The results show that even though in Mill A the average of environmental sound level (85.53±8.dB (A)) was the lowest, but the workers were expose to a higher average level of noise (80.40±6.27 dB (A)). It may be due to the size of the indoor area and arrangement of the sections and devices, the condition of building, and decrement of machineries in Mill A which would require more attention as the workers could not leave the exhaustion devices for a long time. The devices in this factory were quite old and most of the steps of process were carried out manually.

According to the results shown in Table 1, though in sterilizer, nut plant, press, oil room and boiler room the average of environmental sound level in combination of five mills has exceeded the permissible level of 90 dB(A), but the average of personal noise exposure level in all of the sections was below 85 dB(A). The inconsistency of personal noise exposure and environmental sound level at each point may be due to the difference of two methodologies of measurements. In some cases, such as the workshop, the workers were not working at the same section where they had registered for. Moreover in some of the sections like Boiler, the workers monitor the system's performance remotely from inside the Control Room. The obtained result in this part of study is completely in contrast with the results of study done by Uswir [17]. The difference in outcome of two studies may be due to the difference of sampling unit methodology and grouping the respondents as in this study the exposed and non-exposed groups, both have been chosen from the production line. However in study done by Uswir [17], the exposed group has been chosen from production line and non-exposed group from workshop staffs.

Alpha-Amylase Activity

According to the results shown in Table 2, in both of exposed and non-exposed groups, the average of salivary Alpha-amylase (sAA) activity in stimulated condition is higher than resting condition. Indeed, the results show that after 8 hours working at any circumstance of the mill, the workers had been experiencing some endocrine responses. In comparison the mean of sAA activity in resting condition, shows no significant difference between exposed and non-exposed groups (t value=-0.865, p=0.388). However, comparing the means of sAA activity during working situation, in exposed group was significantly higher than non-exposed groups (t value=-3.983, p<0.005). The significant difference of the endocrine response is directly related to the intensity of existing stressor (Noise exposure). The findings related to sAA activity are confirmed by the results of the study done by Myriam [18] who examined the relation between stress-induced sAA activity and revealed that stress responses in sAA significantly predicted stress responses among nurses (r = 0.326; p = 0.025).

Relationship between stress level and risk factors

The relationship between stress level and risk factors statistically has been shown in Table 4 and Table 5. The results of table 4 determine that there is no significant association between selected socio-demographic risk factors and stress level. The finding of this study is confirmed by the study which done by Uswir [17] who concluded that there was not any significant association between job stress and socio-demographic factors. But on the other hand in some cases the outcome of this study is in contrast with the study conducted by Yaw [19] who found that there is a significant association between household factor and distress among breast cancer survivors. It could be due to the gender of the respondents as the respondents in this study are completely male while in study done by Yaw [19], they are totally female. In fact the concern about household for male and female is dissimilar since the females may felt they had inadequate time to balance work and family responsibilities.

Table 5 indicates the association between occupational risk factors and stress level. In this dataset only personal noise exposure was verified as to be associated with occupational stress (χ^2=29.181, p<0.005) among palm oil mill workers. However 100% of the workers from exposed group were experiencing occupational stress, only 43.4% of the workers from non-exposed group were experiencing stress condition. It could be easily justifiable since excessive noise is always identified as an effective

stressor in workplaces; and meanwhile several studies have shown that the secretion of sAA level will be increased under distress condition [20]. The results are affirmed by the consequence of study conducted by Yaw [19]. She also has mentioned that "Significant relationship was found between sAA activities with stress-related symptoms. Similarly Unno [21] found the positive correlation between sAA activity and subjective stress among 20 students. Previous findings [17], [22], [23], support the outcome of this study since in those studies also the significant association between stress and noise exposure level has been determined.

No significant association was indicated between stress level and the other occupational risk factors. Some of the outcome of the current study is not in line with the other studies. For instant, Özdemir [24] found that night shift condition leads the workers to experience the occupational stress. Moreover, Gerber [25] concluded that "Shift work was associated with increased social stress. The contradiction of outcomes could be due to not proportion in number of day and night shift workers in this study, however, the number of the workers in night shift signally decreased and was not sufficient to compare with day shift.

The results from Table 5 show that even though, 66.7% of the workers, who did not use ear plugs, were experiencing stress condition but it is not significantly associated with Occupational stress. The finding of this study seems not to be in line with the study done by Uswir [17] that revealed the workers who used PPE in high noise condition during the work, had a 1.721 fold greater chance to experience stress that the workers who did not use [17]. It could be due to the way of PPE usage by the workers. In fact 65% of the workers reported wearing ear plugs while the majority of them avoided wearing them regularly and correctly due to inconvenient to communication. The mills provided protective equipment for the workers but the way of usage was not strictly observed by the supervisors. Moreover the 35% of the workers who reported not wearing ear plugs may mostly were from the sections that did not need ear plugs.

5. CONCLUSION

The prevalence of occupational stress in excessive noise exposure condition (PNE≥85) was 100% and the results statistically shows that PNE has a direct strong relationship with occupational stress level in terms of Alpha-amylase activity (r_s=0.725, p value<0.005). Personal noise exposure (χ^2=29.181, p <0.005) is the only risk factor (occupational characteristic) which have significant association with occupational stress (Alpha amylase activity). Therefore, this study concluded that in Palm Oil Mill environment, noise is one of the main stressors to increase occupational stress levels and the other risk factors are not significant contributor factors in this regards.

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