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A STUDY ON THE EFFECTS OF NOISE ON INDUSTRIAL WORKERS IN MALAYSIA

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Abstract. This paper presents results of an ergonomic study pertaining to the effect of noise on industrial workers in Malaysia. Three different industries selected for the study were rubber product manufacturing, metal stamping, publication and printing. A questionnaire consisting of 37 questions, covering all possible reported effects of noise on humans, was prepared and served to a total of 120 workers at the above mentioned industries. Responses from the workers were collected for analysis. A Chi-Square test was used to determine whether the effects of noise were statistically significant or not. It is found from the results of the survey, at a level of significance, $\alpha = 0.05$, physiological, hearing loss, auditory, and sleep disturbances effects of noise are statistically significant. However, psychological effect of noise is found to be non-significant.

Keywords: Ergonomics, noise effects, physiological effects, hearing loss effects, auditory effects, psychological effects

Abstrak. Kertas kerja ini mempersembahkan keputusan satu kajian ergonomik berkaitan kesan kebisingan terhadap pekerja industri di Malaysia. Tiga industri berbeza yang telah dipilih untuk kajian ialah pengeluar produk berasaskan getah, syarikat hentakan logam dan syarikat percetakan penerbitan. Satu soal selidik yang mengandungi 37 soalan yang merangkumi semua aduan berkaitan kesan kebisingan terhadap manusia telah disedia dan diberikan kepada 120 pekerja industri yang dipilih. Maklum balas daripada pekerja dikumpulkan sebagai data untuk analisis selanjutnya. Satu pengujian *Chi-Square* telah digunakan untuk menentukan sama ada kesan kebisingan adalah signifikan atau tidak signifikan. Didapati bahawa pada tahap signifikan, $\alpha = 0.05$, fisiologi, kehilangan pendengaran, audiotori dan gangguan tidur adalah kesan kebisingan yang secara statistiknya signifikan. Bagaimanapun, kesan kebisingan terhadap psikologi telah didapati tidak signifikan.

Kata kunci: Ergonomik, kesan kebisingan, kesan fisiologi, kesan kehilangan pendengaran, kesan audiotori, kesan psikologi

1.0 INTRODUCTION

Sound can be measured objectively but noise is a subjective phenomenon. Bridger [1] defined noise as a sound or sounds at such amplitude as to cause annoyance or

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to interfere with communication. Kroemer *et al.* [2] mentioned that noise was psychological and subjective feeling. Single, short tones of low intensity may be considered noise under certain conditions. In fact just as loud, lasting, complex sounds may be deemed noise under other circumstances. Any sound which is annoying or level of sound exceeds 75 dBA may be conceived as noise. The threshold for noise annoyance varies. It depends on the conditions, including the sensitivity and mental state of an individual. Generally, noise can create negative emotions, feeling of surprise, frustration, anger and fear. Noise also delay the onset of sleep, awaken a person from sleep or disturb someone's rest and make it difficult to hear desirable sounds. The effects of noise may produce temporary or permanent alterations in body chemistry, and temporarily or permanently change one's hearing capability too. These could also interfere with some human sensory and perceptual capabilities and thereby degrade the performance of a task [2].

It was reported by Suter [3] that the level of noise necessary to produce adverse effects was greatly dependent upon the type of task. Simple tasks may remain unaffected at noise level as high as 115 dB or above, while more complex tasks may get disrupted even at much lower levels. In many studies, noise was found to degrade human performance. The performance of human being was adversely affected due to noise-induced stresses [4]. Office noise (such as speech), disrupted performance on office-related tasks that would require memory for prose and mental arithmetic whereas office noise without speech disrupted the performance only on mental arithmetic task [5]. Smith [6] cited that noise impaired performance on the focused attention task. Fu *et al.* [7] explored that noise deteriorated the performance of subjects in vowel and consonant recognition task. Cho *et al.* [8] stated that the cortical activity of subjects diminished substantially when exposed to large acoustic sound. They added that when subjects were exposed to a loud acoustic sound, there was an increase in total motor activation.

Hearing loss is one of the most obvious and easily quantified effects of excessive exposure to noise. Its progression however is insidious, in that it usually develops slowly over a long period of time, resulting in the impairment that can lead to handicap level before an individual gets aware of what has happened. While the losses are temporary at first, they become of permanent nature after continuous exposure. There could be some difficulties to provide a treatment to such an effect. Many studies have found hearing losses due to excessive exposure to noise produced by varieties of sources. For example, noise-induced hearing loss was noted in the children of farm families, presumably from the frequent use of tractors [9]. Hearing loss among rock musicians due to loud music had also been reported [10]. Some studies reported hearing loss among the attendees of rock music show [11-13]. The sensory cells' stereocilia and the rootlets which anchor them were found to be the most vulnerable components with respect to noise exposure [14]. Many studies were conducted to investigate the effect of interaction between noise and drugs on hearing

loss. A variety of industrial agent such as lead and mercury, organic solvent, like toluene, xylene, carbon disulfide, asphyxiant and carbon monoxide were also found to produce hearing loss in the presence of noise [15]. The result of a study conducted to explore the effect of existing ambient sound levels in a state psychiatric hospital showed that hearing loss among the patients was the result of exposure to sound levels between 85 to 90 dB [16]. The combined effect of noise and industrial chemicals was also found to cause hearing loss among industrial workers [17]. Electronically amplified sound level generated by the loudspeakers and the headphones were found to produce noise-induced hearing loss among young people [18].

Noise is one of the common sources of sleep disturbance. Several noise factors that influence sleeping are the level of noise, fluctuations, number of exposures, type, time and information content. Individual factors are also important for the effect of noise on sleep. In a noise and sleep research, it was recommended that the night time average sound level ought to be kept below 45 dB in a sleeper's quarters [19]. A study was conducted to investigate infants' response to noise reduction by earmuffs and it was found that with earmuffs, they had less frequent behavioural state changes, spent more time in sleep state, and had longer bouts in the sleep state [20].

Annoyance is the measured outcome of a community's subjective response to various environmental conditions. The sources of noise that affect the community and generate annoyance primarily originate from aircraft, road traffic and rail road. At certain situation, noise from industry, construction and within buildings can also be problematic. Factors directly affecting annoyance due to noise include interference with communication and sleep disturbances. Many studies reported that annoyance was often generated at day-night average sound levels well below 65 dB [21, 22]. Apart from noise exposure level, many other variables such as ambient noise level, time of day and year, location and socio-economic status, were also found to be strongly correlated with noise annoyance [23]. In the study conducted by deJong [24], it was found that annoyance in a previously surveyed community increased by 10% with no change in noise levels.

Noise has been implicated in the development or exacerbation of a variety of health problems, ranging from hypertension to psychosis in human. VanDijk [25] reported that half of twelve field studies showed a positive correlation between noise exposure and blood pressure, while the rest indicated no significant effects. An epidemiological study conducted in England also indicated the spread of heart diseases due to road traffic noises [26]. Psychoneurotic and psychosomatic complaints were also observed due to noise exposures [3, 27].

In the light of the above reported effects of noise, a study was conducted to investigate the effects of noise among industrial workers in Malaysia. This paper presents the outcome of the investigation with the objective of finding ill effects of noise among industrial workers and to suggest specific recommendations to prevent

workers from these effects. The methodology adopted for this study is described and the results are presented. A discussion is highlighted and the paper finally concludes with the important findings of the study.

2.0 METHODOLOGY

The current study involved the noise measurement method and a questionnaire based survey. Subjects for the study were chosen at random among industrial workers from several organizations located in the north of Malaysia. The organizations were the rubber product manufacturing, metal stamping and publication and printing companies. Studies covered the physiological and psychological effects of noise and the auditory, hearing loss and sleep disturbance experience among subjects.

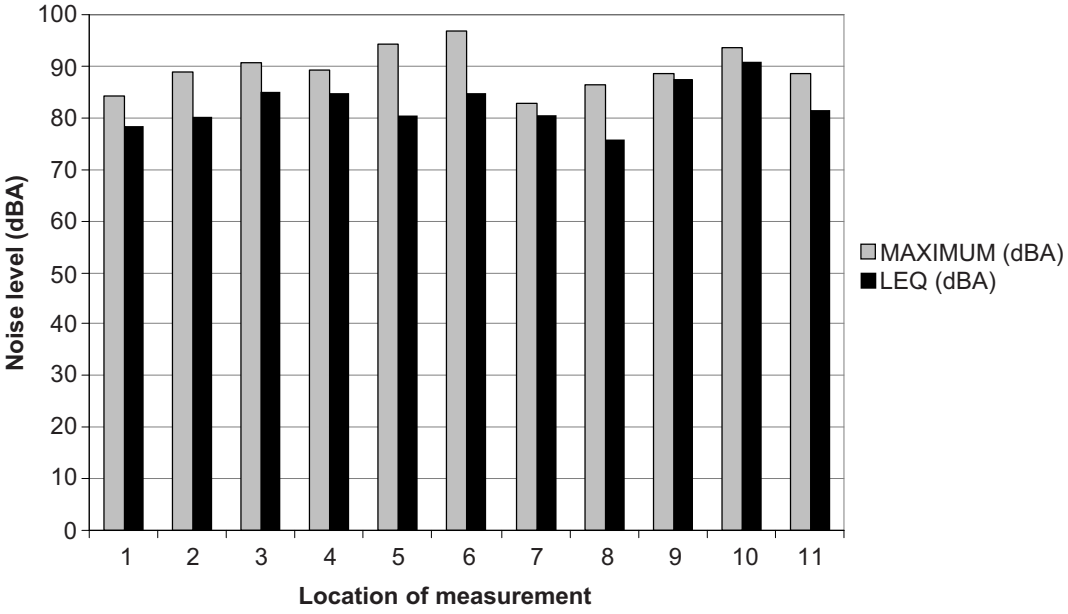
The noise measurement method used a logging dose meter (type 443; make: Bruel & Kjaer, Denmark) to assess the noise level exposure among workers. Visits to industries were made and the noise levels were measured and recorded for different sections of the factories. The questionnaire for the survey comprised of 37 questions on different effects of noise on workers. Each question was provided with three choices of responses, i.e. YES, NO, and UN-SURE**.** A total of 120 workers were selected at random to complete the questionnaires. Responses were collected and analysis was made.

3.0 RESULTS

Figures 1, 2 and 3 show the maximum and average (LEQ) levels of noise for subjects at the rubber product manufacturing, metal stamping and publication and printing companies respectively. Table 1 shows the response of the subjects with respect to the physiological effect of noise. Table 2 provides the effect of hearing loss among the subjects. Tables 3, 4 and 5 show the auditory, psychological and sleep disturbance among the subjects respectively.

4.0 DISCUSSION

Table 1 shows the response of workers of different industries with respect to the physiological effect of noise. It can be seen from Table 1 that maximum percentage of workers in all industries indicated that they did not feel any physiological effect of noise. With respect to hearing loss, maximum percentage of workers indicated that noise did not produce any hearing loss effect, as can be seen from Table 2. Similarly, for auditory, psychological, and sleep disturbance effects of noise, percentage of workers indicating presence of the effect, no effect, and no response from the workers are shown in Tables 3, 4, and 5 respectively.



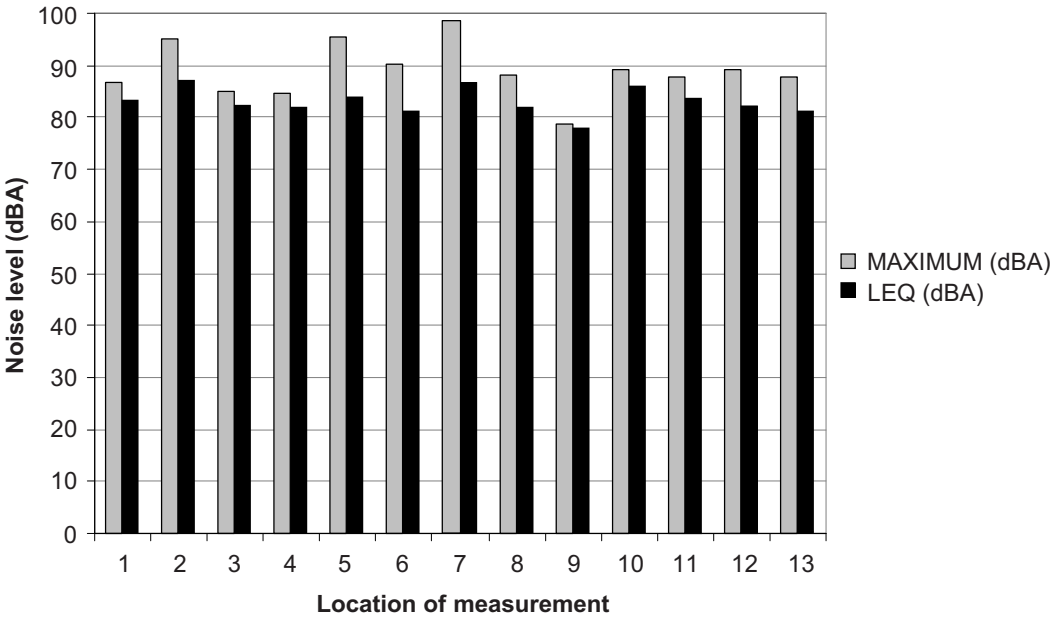
No.	Details	No.	Details
1	Preparation section	7	Vulcaniser section
2	Moulding section	8	Finish goods inspection section
3	Skim calender section	9	Air compressor room
4	Mixing section	10	Boiler room
5	Cutting section	11	Maintenance workshop
6	Assembly section		

Figure 1 Graphical comparisons of noise levels prevailing at different sections in rubber product manufacturing company

4.1 Statistical Analysis of the Data Obtained

In order to determine whether the effects of noise on industrial workers are significant or not, data was analyzed through a statistical test of significance. The most common type of test used to carry out bivariate analysis in practice is Chi-square test. The Chi-square test may be used to find whether the two variables are dependent or independent. However, it does not tell anything about the nature of relationship between the two variables.

Generally, the null hypothesis (H_0) suggests that two variables are independent of each other. The alternative hypothesis (H_1) suggests that they are not independent of each other i.e. there is a relationship between the two variables. In the present study, one variable is represented by the kind of industrial environment or site while the second variable is indicated by the presence or absence of effect of noise on the industrial



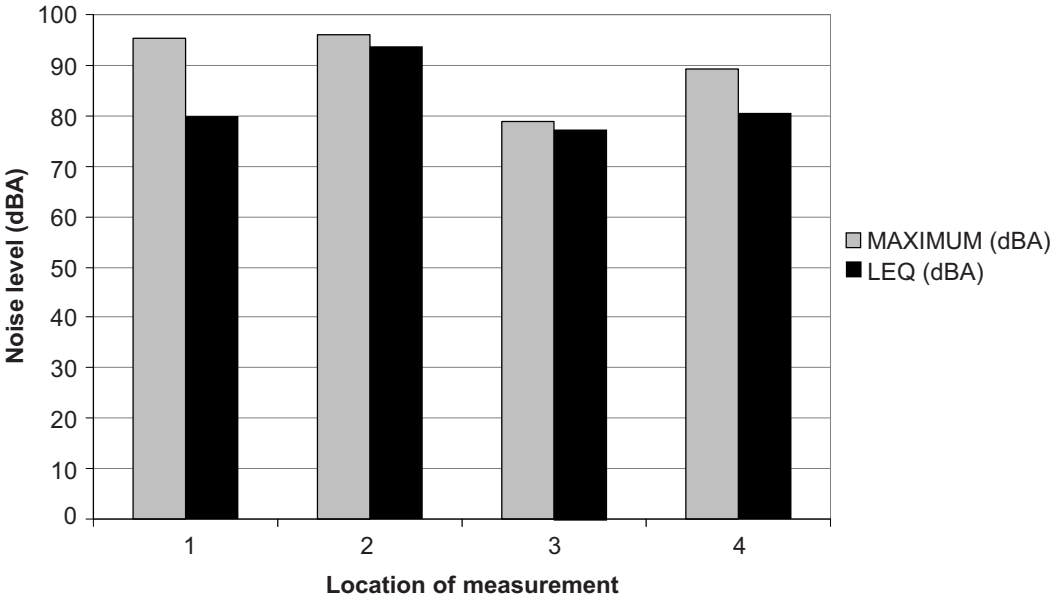
No.	Details	No.	Details
1	Turret bending section	8	Multi spindle section (cell a)
2	Turret punching section (cell a)	9	Multi spindle section (cell b)
3	Turret punching section (cell b)	10	Escomatic section
4	Low stamping section	11	Cnc-1 section (cell a)
5	Medium stamping section (cell a)	12	Cnc-1 section (cell b)
6	Medium stamping section (cell b)	13	Cnc-2 section
7	Heavy stamping section		

Figure 2 Graphical comparisons of noise levels prevailing at different sections in metal stamping company

workers. The observed (O) and expected (E) frequency values were calculated. The null hypothesis was tested at a confidence level of 95%, confidence coefficient (α) is 0.05 and accuracy ±5%. Chi-square value was calculated using the following equation [28]:

$$\text{Chi-square value} = \frac{(O-E)^2}{E} \tag{1}$$

Expected value was calculated using the probability. When observed value is significantly greater than the expected value, then a relationship is said to exist between two variables, otherwise the relationship does not exist.



No.	Details	No.	Details
1	Pre-press section	3	Reel stand section
2	Press section	4	Packaging section

Figure 3 Graphical comparison of noise levels prevailing at different sections in publication company

Table 1 Percentage of workers indicating presence of effect, no effect, and no response with respect to the physiological effect of noise

Name of industry	Presence of effect (%)	No effect (%)	No response (%)
Rubber product	27	54	19
Metal stamping	25	70	5
Publication printing	30	56	14

Table 2 Percentage of workers indicating presence of effect, no effect, and no response with respect to the hearing loss effect of noise

Name of industry	Presence of effect (%)	No effect (%)	No response (%)
Rubber product	43	45	12
Metal stamping	32	64	4
Publication printing	40	51	9

Table 3 Percentage of workers indicating presence of effect, no effect, and no response with respect to auditory effect of noise

Name of industry	Presence of effect (%)	No effect (%)	No response (%)
Rubber product	81	17	2
Metal stamping	66	29	5
Publication printing	70	19	11

Table 4 Percentage of workers indicating presence of effect, no effect, and no response with respect to the psychological effect of noise

Name of industry	Presence of effect (%)	No effect (%)	No response (%)
Rubber product	52	35	13
Metal stamping	51	41	8
Publication printing	53	38	9

Table 5 Percentage of workers indicating presence of effect, no effect, and no response with respect to the sleep disturbances effect of noise

Name of industry	Presence of effect (%)	No effect (%)	No response (%)
Rubber product	35	56	9
Metal stamping	55	38	7
Publication printing	40	53	7

4.1.1 Data Analysis for the Physiological Effects

H_0: Physiological effects of noise on industrial workers are independent of types of industry.

H_1: Physiological effects of noise on industrial workers depend on the types of industry.

Table 6 shows the results of Chi-square test for the physiological effects of noise. From Chi-Square distribution table [28], for the level of significance, $\alpha = 0.05$ and the degree of freedom (dof) = 4, the critical value of Chi-square obtained is 9.48773. It is shown in Table 6 that the computed test statistics is 71.03 and this exceeds the critical value, hence the null hypothesis is rejected. This means that at the level of significance $\alpha = 0.05$, there exists a significant relationship between the physiological effects of noise on industrial workers and the types of industries.

Table 6 Computation of test statistic of physiological effects

Name of industry	Responds	O	E	$\frac{(O-E)^2}{E}$
Rubber product	Presence of effect	172	173.33	0.01
	No effect	343	384.00	4.38
	Un-sure	125	82.67	21.67
Metal stamping	Presence of effect	157	173.33	1.54
	No effect	449	384.00	11.00
	Un-sure	34	82.67	28.65
Publication printing	Presence of effect	191	173.33	1.80
	No effect	360	384.00	1.50
	Un-sure	89	82.67	0.48
			Total	**71.03**

4.1.2 Data Analysis for the Hearing Loss Effects

H_0: Hearing loss effects of noise on industrial workers are independent of types of industry.

H_1: Hearing loss effects of noise on industrial workers depend on the types of industry.

The results of Chi-square test for hearing loss effects of noise on industrial workers are shown in Table 7. From Chi-Square distribution table, for the level of significant, $\alpha = 0.05$ and the degree of freedom (dof) = 4, the critical value of the Chi-square obtained is 9.48773. It is also shown that the test statistics is 14.73 and exceeds the critical value. Thus, the null hypothesis is rejected. This means that at the level of

Table 7 Computation of test statistic of hearing loss effects

Name of industry	Responds	O	E	$\frac{(O-E)^2}{E}$
Rubber product	Presence of effect	68	61.00	0.80
	No effect	73	86.00	1.97
	Un-sure	19	13.00	2.77
Metal stamping	Presence of effect	51	61.00	1.64
	No effect	103	86.00	3.36
	Un-sure	6	13.00	3.77
Publication printing	Presence of effect	64	61.00	0.15
	No effect	82	86.00	0.19
	Un-sure	14	13.00	0.08
			Total	**14.73**

significance $\alpha = 0.05$, there is a significant relationship between hearing loss effects of noise on industrial workers and the types of industries.

4.1.3 Data Analysis for the Auditory Effects

H_0: Auditory effects of noise on industrial workers are independent of the types of industry.

H_1: Auditory effects of noise on industrial workers depend on the types of industry.

The results of Chi-square test for the auditory effects of noise on industrial workers are presented in Table 8. From Chi-Square distribution table, for the level of significant, $\alpha = 0.05$ and the degree of freedom (dof) = 4, the critical value of the Chi-square obtained is 9.48773. It is shown in Table 8 that the test statistics is 9.85 that exceeds the critical value and hence, the null hypothesis is rejected. This means that at the level of significance $\alpha = 0.05$, there exists a significant relationship between auditory effects of noise on industrial workers and the types of the industries.

Table 8 Computation of test statistic of auditory effects

Name of industry	**Responds**	O	E	$\frac{(O-E)^2}{E}$
Rubber product	Presence of effect	65	58.00	0.85
	No effect	13	17.00	0.94
	Un-sure	2	5.00	1.80
Metal stamping	Presence of effect	53	58.00	0.43
	No effect	23	17.00	2.12
	Un-sure	4	5.00	0.20
Publication printing	Presence of effect	56	58.00	0.07
	No effect	15	17.00	0.24
	Un-sure	9	5.00	3.2
			Total	**9.85**

4.1.4 Data Analysis for the Psychological Effects

H_0: Psychological effects of noise on industrial workers are independent of the types of industry.

H_1: Psychological effects of noise on industrial workers depend on the types of industry.

The results of the Chi-square test are shown in Table 9. From Chi-Square distribution table, for the level of significant, $\alpha = 0.05$ and the degree of freedom

Table 9 Computation of test statistic of psychological effects

Name of industry	Responds	O	E	$\frac{(O-E)^2}{E}$
Rubber product	Presence of effect	251	249.33	0.01
	No effect	167	182.00	1.24
	Un-sure	62	48.67	3.65
Metal stamping	Presence of effect	245	249.33	0.08
	No effect	196	182.00	1.08
	Un-sure	39	48.67	1.92
Publication printing	Presence of effect	252	249.33	0.03
	No effect	183	182.00	0.01
	Un-sure	45	48.67	0.28
			Total	**8.30**

(dof) = 4, the critical value of the Chi-square obtained is 9.48773. Table 9 reveals that the computed test statistics is 8.30 which is less than the critical value and hence, the null hypothesis is accepted. The data show that there is no psychological effects of noise on industrial workers and the types of industries.

4.1.5 Data Analysis for the Sleep Disturbances Effects

H_0: Sleep disturbances effects of noise on industrial workers are independent of types of industry.

H_1: Sleep disturbances effects of noise on industrial workers depend on the types of industry.

The results of the Chi-square test are shown in Table 10. From Chi-Square distribution table, for the level of significant, $\alpha = 0.05$ and the degree of freedom (dof) = 4, the critical value of the Chi-square obtained is 9.48773. From Table 10, it is clear that the value of test statistics is 11.72 and exceeds the critical value. Therefore, the null hypothesis is rejected. This means that at the level of significance $\alpha = 0.05$, there is a significant relationship between sleep disturbances effects of noise on industrial workers and the types of industries. The results of Chi-square tests are summarized in Table 11.Various effects of noise on humans have been a topic of research especially in situations where they are exposed to high levels for a long duration. Many countries have laid down standards with regard to the safe limit of noise to which humans should be exposed. According to many standards, the noise level exceeding 90 dB [29] can produce adverse effects on humans and therefore, one should not ignore its ill effects. The results of the present study discussed above were supported from the previous studies conducted in this field and they also indicated those effects of noise that have significantly affected

Table 10 Computation of test statistic of sleep disturbances effects

Name of industry	Responds	O	E	$\frac{(O-E)^2}{E}$
Rubber product	Presence of effect	42	52.33	2.04
	No effect	67	58.33	1.29
	Un-sure	11	9.33	0.30
Metal stamping	Presence of effect	67	52.33	4.11
	No effect	45	58.33	3.05
	Un-sure	8	9.33	0.19
Publication printing	Presence of effect	48	52.33	0.36
	No effect	63	58.33	0.37
	Un-sure	9	9.33	0.01
			Total	**11.72**

Table 11 Results of the statistical test in a summarized form with reference to the five effects of interest

No.	Type of effect	Relationship between the type of effect at different proposed sites $\alpha = 0.05$
1	Physiological effects	Significant
2	Hearing loss effects	Significant
3	Auditory effects	Significant
4	Psychological effects	Not significant
5	Sleep disturbances effects	Significant

the industrial workers. The problems faced by the workers due to high levels of noise existing at their workplaces are severe and must be critically analyzed and properly dealt with.

5.0 CONCLUSION

Present study provided important information pertaining to the effect of noise among industrial workers. A questionnaire based survey was carried out to get responses from 120 workers employed in three different industries. The primary data, thus collected, was analyzed using Chi-square statistical technique and it was found that except psychological behavior, the physiology, hearing capability, auditory communication and sleep of the industrial workers were significantly affected by the existing noise levels. These findings were supported from the studies conducted by previous researchers. Even though the minimum requirement of noise exposure is met, there are significant effects of the noise on workers in Malaysia**.** Thus there is a need

for an immediate intervention of the management and the system designers to make and implement effective plans to curb the adverse effects of noise in order to ensure health, safety and to enhance efficiency and comfort of the workers at the workplace.

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