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A Study of Occupational Noise Exposure among Toll Tellers at Toll Plaza in Malaysia

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Abstract— **Toll tellers working at toll plaza have potential of exposure to high noise from the vehicles especially for the peak level of sound emitted by the heavy vehicles. However, occupational exposures in this workplace have not been adequately characterized and identified. Occupational noise exposure among toll tellers at toll plaza was assessed using Sound Level Meter, Noise Dosimeter and through questionnaire survey. These data were combined to estimate the work shift exposure level and health impacts to the toll tellers by using statistical analysis. Noise Dosimeter microphone was located at the hearing zone of the toll teller which working inside the toll booth and full-period measurements were collected for each work shift. The measurements were taken at 20 toll booths from 6.00am to 2.00pm for 5 days. 71 respondents participated in the survey to identify the symptoms of noise induced hearing loss and other health related problems among toll tellers. Results of this study indicated that occupational noise exposure among toll tellers for Mean Continuous Equivalent Level, L_{eq} was 79.2 ± 1.4 dB(A), Mean Maximum Level, L_{max} was 107.8 ± 3.6 dB(A) and Mean Peak Level, L_{peak} was 136.6 ± 9.9 dB. The Peak Level reported statistically significantly at 140 dB, the level of TLV recommended by ACGIH. The research findings indicated that the primary risk exposure to toll tellers comes from noise that emitted from heavy vehicles. Most of the toll tellers show symptoms of noise induced hearing loss and annoyed by the sources of noise at the toll plaza.**

Index terms: noise; exposure; toll teller; occupational

I. INTRODUCTION

Road traffic is a major source of environmental noise in urban areas likewise at the toll plaza the noise from the road traffic is an occupational noise to the workers. In the highway system, highway toll plaza employees, highway maintenance and repair crews, and highway inspector may be exposed to sound levels hazardous to hearing [1]. Traffic noise also can produces disturbance and inversely impacts people more than other form of noise [2].

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In Malaysia, exposures in the workplace were regulated under the Factories and Machinery Act (FMA), 1967 and also the more comprehensive Occupational Safety and Health Act (OSHA 1994) enacted in 1994. With the increased coverage under the Act (all workers except those in the Armed Forced and work on board ships) and the objects of the Act clearly defined multi-pronged efforts are being made to ensure safety and health of workers and also all those at workplace. A specific occupational noise exposure to the workers was enacted through Factories and Machinery (Noise Exposure) Regulations 1989 that covers mostly the industries involved in manufacturing, construction, mining and quarrying however there is no specific legal noise exposure limit stipulated under OSHA 1994. The National Institute of Occupational Safety and Health (NIOSH) recommended exposure limit (REL) of 85 dB(A) for occupational noise exposure for 8 hours average sound pressure level [3]. The American Conference of Government Industrial Hygienists (ACGIH) also has recommended threshold limit values (TLV) for occupational noise. The TLV is exceeded when the dose is more than 100% or sound level 85 dB(A) for 8 hours exposure [4].

Highway traffic noise is one of the prevalence sources of noise. Road traffic is the most widespread source of noise in all countries and the most prevalent cause of annoyance and interference. Employees working at toll booth are exposed to the extended and continuous traffic noise. Sustained noise levels of this nature may cause hearing loss, induce fatigue or stress, and reduce worker's productivity. The annoyance and discomfort related to the continuous noise exposure may create an unpleasant working condition and may affect the hospitality of the toll tellers and their attitude toward customers. Furthermore, the noise level may hinder communication with customers and may compromise safety.

Exposure to traffic noise has a number of acute and chronic effects on human [5][6][7]. It disturbs sleep, and may cause insomnia. It can cause annoyance [8], hearing loss, mental disorders and adverse physiological and psychological impacts [9] as well as increase in the activity of endocrine glands, produce high blood pressure, affects heart rate and cause changes in blood composition [6].

According to NIOSH, noise-induced hearing loss is the most common occupational injury. High levels of occupational noise remain a problem in all regions of the world. Occupational noise is a widespread risk factor, with a strong evidence base linking it to an important health outcome. This occupational noise is associated with the workplace, and therefore the responsibility of employers as well as individuals. The assessment at the workplace

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particularly important to identify the workplace hazard and practical measures can be use to reduce exposure to occupational noise.

Toll plaza is one of the noisy places. Source of noise emission at toll plaza area comes from the vehicle that varies. The amount of noise emitted by a vehicle depends mainly on two factors, namely type of vehicle and its speed. Each vehicle represents a complex noise source. Actually one vehicle is composed of numerous sources: engine, air inlet and exhaust, transmission, tire/road surface and others. Moreover the power and directivity of these sources depend on others variables such as speed and mode of operation[10].

Toll booths have certain features which are necessary for the business of toll collections but allow the transmission of noise. Open communication windows, often used in toll booths, facilitate essential communication and monetary transactions. However, the vehicle noise generated outside the booth is easily transmitted into the booth via the open window. Typical transactions between toll tellers and patrons involve toll tickets, and the exchange of cash. Direct visual and physical contact between patrons and attendants is made possible by the open communication window. One disadvantage is that vehicle noise generated outside the booth is easily transmitted into the booth via the open window. The booth structure acts as a partially open enclosure which may amplify road noise due to sound reflections off of rigid surfaces and reverberation within the enclosure[11].Toll tellers working at toll booth are exposed to extended, continuous traffic noise.

Thus the objective of this study is to determine the effect of occupational noise from road traffic on toll tellers.

II. METHODS

A. *Toll Booth Selection*

A typical toll collections facility, the Sungai Besi Toll Collection Plaza, was selected as the survey location due to its high traffic volume and high noise level. The toll plaza is located at Seri Kembangan, Selangor. The toll plaza contains 32 toll booths of two different sizes serving, at times, lanes of traffic. The smaller tollbooths measure 1.80 meters long by 1.36 meters wide by 2.45 meters high and are located on the extremes of the plaza to serve traffic movement in entry direction. The larger tollbooths measure 2.43 meters long by 1.40 meters wide by 2.60 meters high and are located at the side of the plaza to serve traffic movement in exit direction. The structure of the booths is made of glass, aluminum and stainless steel. Concrete crash impact barriers have been positioned in line with the booths. The lanes are surfaced in concrete. Above the ground is an overhead canopy. A preliminary inspection revealed that the booths were well built and did not appear to substantially contribute to the noise. Sound transmission through the openings of the toll booths seemed to be the main noise issue.

B. *Instruments*

The noise exposure measurement data of this research project has been achieved with one unit of an Integrating Sound Level Meter (ISLM) with spectrum analyzer Bruel & Kjaer Investigator Type 2250-L, three unit of noise logging dosimeter Bruel & Kjaer Type 4445E, one unit of noise logging dosimeter Quest Model Q-300 and two unit of sound calibrator Bruel & Kjaer Type 4231 and Quest QC-20.
The configuration of the sound level meter is as follow:

- Range - 70 - 140 dB.
- Bandwidth - 1/3 octave.
- Peaks over - 140 dB.
- Time weighting - Slow.
- Frequency weighting - A.
- Spectrum – Slow time weighting and L frequency weighting.
- Global measures – A&L frequeny weightings.
- Logging – 1 record/Second.
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The configuration of the dosimeter is as follows:

- Range – 70–140 dB.
- Time weighting-Slow.
- Frequency weighting-A.
- Frequency weighting for peaks-C.
- Exchange rate-3 dB.
- Threshold-80 dB.
- Criteria level-85 dB.
- Logging-1 record/minute.

C. *Noise Measurement*

Noise level was measured by using equipment as stated above. This measurement is important to identify the level of sound at the toll plaza area.

Sampling strategy was referred to NIOSH Occupational Exposure Sampling Strategy Manual and ISO 9612 Acoustics – Guidelines for the measurement and assessment of exposure to noise in a working environment. Sampling was done continuously for entire duration of selected work shift from 6.00 am to 2.00 pm. The total working hours for the work shift is 8 hour. The sampling measurements include the toll tellers which work in the toll booth of heavy vehicle lanes: entry lanes of M1 and M2 and exit lanes of K22 and K23.

Personal noise exposure of toll tellers was done by using a noise dosimeter B&K type 4445E and Quest Q-300. Personal noise exposure is a measurement to indicate the level on how much the worker was exposed to the noise in the percent dose. For personal sampling, the microphone is attached in hearing zone of the worker. The placement of the microphone is important in estimating the worker's exposure. ISO 9612-1997 specifies that the microphone should be located at the collar or on the shoulder of the person approximately 0.1m to 0.3m from the entrance of the external canal of the ear receiving the higher value of the equivalent continuous A-weighted sound pressure level[12].

Shielding by presence of employee and other objects between the noise source and microphone should be avoided. Dosimeters were calibrated at the beginning and end of each shift. Full shift levels were measured using slow response and A-weighting, and data were recorded. The data was set to the ACGIH recommended level, and used a 3 dB Exchange Rate,

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80 dB(A) threshold, and 85 dB(A) criterion level. Full-shift work exposure levels data were compared to TLVs of ACGIH recommended level. The reliability of the noise data will depend on the employee cooperation in the proper use of the dosimeter. The following are to ensure employee cooperation in noise dosimeter.

a) Inform the employees about the purpose of measurement.
b) Explain the importance of the accuracy of noise data in assessing the need for noise control.
c) Emphasize the importance of wearing it all the time during the measurement period.
d) Explain the consequences of tampering with the microphone - shouting in it, using it to knock doors, etc.

The calibration was checked before giving out dosimeters and after the end of the measurement period. The start and stop time of the dosimeters had been noted.

Monitoring area is a measurement to indicate the level of noise at the toll plaza area. Noise measurement was measured at the outside of the toll booth as a reference level of noise level that was emitted from the vehicles. A-weighted SPL measurements of 2 minutes duration each were made outside of the tool booth by using Sound Level Meter B&K type 2250-L. Each location was sampled three times for the entire duration of work shift. The sound level meter was calibrated prior to each day of sampling.

D. Questionnaires

Survey has been done by giving questionnaires form to the toll tellers to get the demographic data and feedbacks from the toll tellers on how their perception and sensitivity toward noise exposure at the workplace. Questionnaires were given to the worker by the supervisor. The questionnaire is divided into four sections that are demographic, workplace information, perception toward noise and symptoms of potential NIHL. Awareness, satisfaction and other subjective effects related to health in term of auditory and non auditory effects were also included in the questionnaires.

E. Analysis data

Measurement and survey data were analyzed by using statistical tools, SPSS 16 software. Descriptive statistics were computed for 8 hr work shift and t-test was conducted to determine if mean noise level between certain variables had statistically significant differences. P-values less than 0.05 were considered statistically significant.

III. RESULT

A. Monitoring Area

A total 60 Sound Pressure Level (SPL) measurement were made at 4 locations outside of the toll booth at toll plaza. The A-weighted noise levels recorded during these measurements were described in Table 1.

Mean Minimum level recorded was 70.42 ± 2.27 dB(A), Mean Maximum level was 91.78 ± 3.03 dB(A) and Mean Peak level was 112.48 ± 5.12 dB.

B. Noise Dosimeter Measurement

Table 2 shows the result of the work-shift dosimeter measurements. 20 measurements were enrolled in the study and toll tellers wore dosimeters for a single work-shift from 6.00am to 2.00pm. All work-shift scheduled for 8 hours (480 min), and mean measurement duration was 378 ± 64 minutes. Mean Dose for 8 hours was 22 ± 12 % Dose. Mean Maximum Level, L_{max} was 107.8 ± 3.6 dB(A) Mean Peak Level, L_{peak} was 136.6 ± 10 dB(C) and Mean Continuous Equivalent Level, L_{eq} was 79.2 ± 1.4 dB(A).

Table 1: Sound Pressure Level measurement at a location outside of toll booth

SPL	*Range*	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
SPL at point 1 (Outside toll booth M1)					
L_{min}	3.2	69.7	72.9	71.2	1.01
L_{max}	14.9	84.6	99.5	90.3	3.57
L_{peak}	11.7	107.1	118.8	112.17	3.81
SPL at point 2 (Outside toll booth M2)					
L_{min}	6.3	67.6	73.9	71.60	1.47
L_{max}	19.5	84.4	103.9	90.90	6.30
L_{peak}	18.8	105.4	124.2	112.48	5.12
SPL at point 3 (Outside toll booth K22)					
L_{min}	4.7	69.6	74.3	71.13	1.26
L_{max}	6.1	87.2	93.3	90.50	1.98
L_{peak}	7.3	107.7	115.0	110.91	2.37
SPL at point 4 (Outside toll booth K23)					
L_{min}	8.6	65.5	74.1	70.42	2.27
L_{max}	11.2	87.1	98.3	91.78	3.03
L_{peak}	12.2	106.4	118.6	111.93	3.48

Table 2: Noise Dosimeter Results

Parameter	Range	Minimum	Maximum	Mean	Std. Deviation
Sampling duration in minutes	228	218	446	378.15	64.03
Dose Measurement	45.0	9.0	54.0	17.98	10.91
Dose Projected 8 Hours	49.2	11.7	60.8	22.52	11.98
Max Level	12.7	102.6	115.3	107.81	3.62
Peak Level	29.6	119.3	148.9	136.63	9.90
Continuous Equivalent Level	7.1	75.7	82.8	79.16	1.44

8 (40%) measurements exceeded the ACGIH Recommended limit, TLVs for Peak level (140 dB(C)) and Maximum Level, 115 dB(A) shown in Figure 1. The Peak Level of the 20 ND measurements, t-test indicated statistically significant of Peak Level at 140 dB(C) for the toll

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tellers exposure (t-test, $p<0.05$). The L_{eq} of the 20 ND measurements, t-test indicated no statistically significant of L_{eq} exceeded 85 dB(A) for the toll tellers (t-test, $p<0.05$). The L_{max} of the 20 ND measurements, t-test indicated no statistically significant of L_{max} exceeded 115 dB(A) for the toll tellers (t-test, $p<0.05$).64.8 % (46) of respondents show that they had symptoms of NIHL (Figure 1).

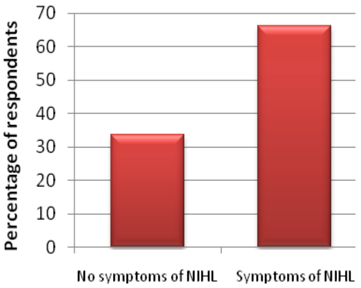

Figure 1: Percent of respondents' had symptoms of NIHL

Most of the respondents were experienced headache and easily to get angry. The percentage of 70.4 % (50) respondents got headache and 46.5 % (33) respondents were easily to get angry. Other problems are ringing in ears and hypertension. There were seven (7) respondents who don't experience any problems due to noise exposure (Figure 2).

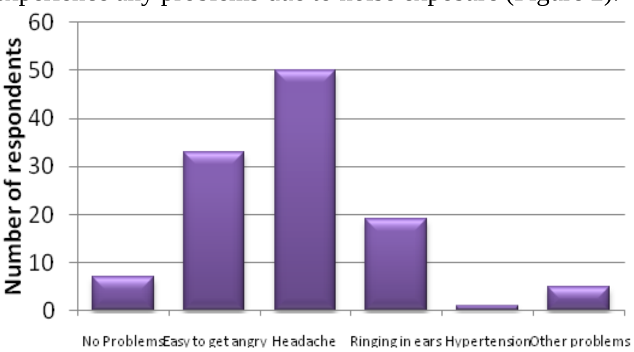

Figure 2: Number of respondents' experienced problems due to noise exposure

Toll tellers who work for more than five (5) years reported more of symptoms of NIHL. Out of 26.8 % (19) toll tellers that work for more than five (5) years, 78.9 % (15) of them had symptoms of NIHL (Figure 3).

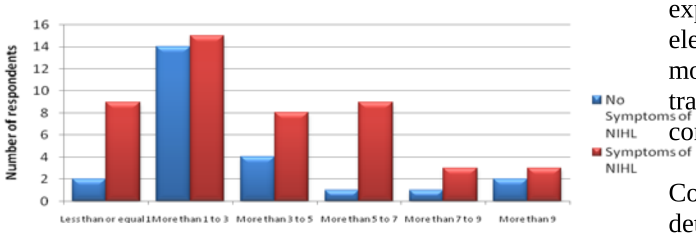

Figure 3: Duration of working and symptoms of NIHL

Between female and male there was no significant difference in term of symptoms of NIHL. 64.2 % (34) of female had symptoms of NIHL while male 72.2 % (13) (Figure 4).

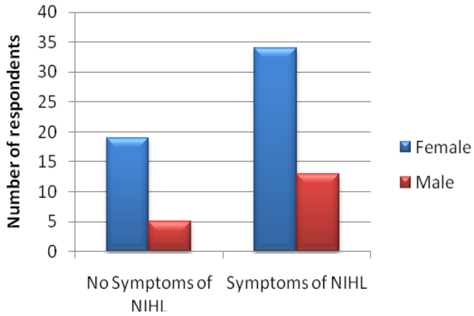

Figure 4: Gender and symptoms of NIHL

Bivariate Correlation was also performed to determine if two variables are linearly related to each other. Correlation for the relationship between annoyance and perceived noisiness was performed. The result shows that the relationship between two variables is significantly correlated with positive medium correlation and the correlation coefficient is 0.395.

IV. DISCUSSION

The results of this study indicated that toll tellers are at risk of NIHL and annoyance from chronic exposure to high noise level especially for the peak level. The nature of the task and the location of the toll teller at the workstation (toll booth) are in proximity to the source of noise that contributes to the over exposure to the noise.

It's generally agreed with the limited literature available on occupational noise exposure to the toll teller at the toll plaza. A study of traffic noise exposure to the traffic policeman would be a good reference of the exposure to the traffic noise for the worker working closely with the source of noise. A study of traffic noise exposure to the traffic policeman done by Ingle S.T. indicates that the acceptable limit exceeded and the result has proven of NIHL among them (Ingle S.T., 2005). This study is base on the combination of the noise sources from many types of vehicle on the road.

In this case, NIOSH recommended a hearing conservation program (HCP) for workers who are exposed to the noise at or above the recommended exposure limit (REL), L_{eq} 85 dB(A), L_{max} 115 dB(A), and L_{peak} 140 dB. The program objective is to prevent NIHL among the worker who over exposed to noise in the noisy working environment. The elements of the programmed includes setting up the policy, monitoring of noise at workplace, hearing protection devices, training, audiometric testing and other activities that can control the risk of hazard from noise exposure.

Control of noise in the workplace is needed to avoid detrimental health effects as well as workers' satisfaction [13]. There is hierarchy of control in controlling noise at the workplace; the application of engineering control, administrative control, and the use of hearing protection device (HPD). Application of engineering noise control at the toll plaza is quite complicated with the sources of noise mostly generated from the traffic. The reduction can be made by controlling noise at the source, path, and receiver. Reduction of noise at the source is beyond the control of the toll plaza operator. There is a regulation which regulated the maximum sound level permitted for motor vehicles which

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known as Environmental Quality (Motor Vehicle Noise) Regulations 1987. This regulation is enforced by the DOE and it is important in controlling the noise emitted from the vehicles (source). Designing of the toll booth is important in reducing of the noise at the path. Consideration should be made in reducing the noise level inside the toll booth from the absorption, reflection and reverberant of sound and the prevalence and effectiveness of noise control deserves further evaluation. Administrative controls, such as shorter work shift, worker rotation may also be utilized to reduce the exposure of noise. Toll booth at the passenger lanes may be less noisy and further measurement of the noise level needs to evaluate the level of noise at that area.
The results of this study can be applied on the other toll plaza that received a high volume of traffic.

V. CONCLUSIONS

Toll tellers working at toll plaza appear to have substantial over exposure to noise. The most critical exposure was the peak level of sound emitted from the heavy vehicles such as buses and trailers. Despite the over exposure to noise will affect the health (hearing loss), the level of noise also reported significantly annoyance and had disturbed the task of toll tellers. Based on questionnaire results, majority of toll tellers experiences symptoms of NIHL. Further evaluation of a toll teller ability to hear by audiometric testing may be needed to assess the status of NIHL among toll tellers. The control of noise at the toll plaza are highly recommended through the implementation of engineering or administrative noise control or the use of hearing protection that suite with the task during working. Hearing Conservation Programmed should be established to prevent the risk of NIHL.
From the study it can be concluded that:

i) Toll tellers are at risk exposed to high level of noise which significantly exceeded TLVs.
ii) The sources of noise at toll plaza emitted mostly from the heavy vehicles, and
iii) Majority of the toll tellers perceived noisy and getting annoyed by the sources of noise at toll plaza. Most of them shows symptoms of NIHL

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