SEASONAL VARIATION OF AIR POLLUTION AND NOISE EXPOSURE, PSYCHOLOGICAL STRESS AND PHYSICAL HEALTH AMONG TRAFFIC POLICE OFFICERS

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ABSTRACT

Malaysian traffic police officers particularly in Kuala Lumpur spent most of their working time outdoors. Hence, they are highly susceptible to health risk resulted from vehicular-related air pollutants and noise exposure levels. Their health might fluctuate throughout the year due to seasonal variation of weather. This study explored the variation of air pollutants and noise exposure levels among 328 traffic police officers and how this variation influences their psychological and physical health. This is a repetitive cross-sectional study where data was collected in three different seasons; Dry, Wet and Inter-Seasons in Kuala Lumpur and several rural areas. Dustrak was used to measure the level of PM_{10}. Sound Level Meter was used to measure the noise levels. Standardised Global health and global stress questionnaire were used to measure their perceived levels of stress, health, noise and air pollution. The highest level of PM_{10} found in urban area was recorded during the Dry Season and the lowest level was during the Wet Season. During Dry season, the PM_{10} level in Kuala Lumpur ($0.27 mg/m^3$) exceeded the permissible exposure level (PEL). The noise levels exceeded the PEL in all seasons for both urban and rural areas. The difference in measured PM_{10} and noise levels was significant between each season. The global health and stress were also significantly different across seasons. The poorest level of perceived health and stress was recorded during Wet Season. During Dry Season, higher level of stress and health were significantly correlated with higher level of noise and air pollutants. During Wet Season, higher level of stress and health were significantly correlated with lower level of noise and air pollutants. This study confirmed that level of health and stress of respondents varied across seasons and related to the level of air pollution and noise in each season.

Keywords: Health, noise, PM_{10}, stress, traffic police officers.

INTRODUCTION

Levels of air pollution varied across seasons due to many factors such as wind direction and velocity, humidity, temperature, ground surface and human activities. For example, in temperate countries, the levels of particulate matters were consistently found to be highest during cold season due to the burning of fuel for heating systems [1, 2]. In Malaysia, as a tropical country annual variation of air pollutants particularly particulates is largely influenced by the levels of rainfall throughout the year [3, 4]. Particulates was commonly recorded as the highest concentration of air pollutants in major cities like Kuala Lumpur [5]. The level of particulates was highest during the Southwest Monsoon or dry season and lowest during the Northeast Monsoon or wet season. The low level of particulates found during wet season is due to the wash-out process in the atmosphere [3, 4].

Workers whose work are mostly outdoor such as traffic police officers, traffic controllers, and stall sellers are at risk to the hazardous health effect of air pollution exposure. For instance, Malaysian traffic police officers particularly in major city like Kuala Lumpur needs to be on the road for cumulatively almost eight hours daily to control heavy road traffic even during heavy rainfall. Hence, they are exposed directly to air pollution and noise from vehicles. Based on previous findings, their level of air pollutant exposure is theoretically varied with different season and different time. Research in Italy (PM_{10} = 153 $\mu g/m^3$) [1] and Czech Republic ($PM_{2.5}$ = 33.2 ± 39.7 $\mu g/m^3$) [6] showed that the highest personal exposure to particulates among traffic police officers was in winter. With reference to daily variation, the highest level of particulates exposure among traffic police officers recorded was during morning shift [1, 7].

These variation in air pollution levels hypothetically leads to the variation in mental and physical health as pollutants may interact and disturb the normal function of human body. Several previous findings explored the seasonal variation of mental health among population though none of them specifically focus on traffic police. For example, a study involving Americans and Australian showed that the level of anxiety was significantly highest in winter and lowest in summer [8, 9]. However, this finding is not consistent where another study which compared this variation between temperate country (Norway) and tropical country (Ghana) indicated that it was only significant in Norway but not in Ghana [10]. Apart from mental and psychological health, several studies measured the seasonal variation of physical health. In Korea, higher level of air pollution were found to be significantly associated with higher blood pressure and the way they associated were varied with different seasons [11]. In this study, it was found that higher level of PM_{10} and NO_2 significantly associated with higher

level of blood pressure during summer and SO_2 and O_3 was significantly associated with higher level of blood pressure during winter. Similar trend was found for mortality rate where highest mortality rate was recorded during winter and lowest during summer [12]. Different season may reflect different human activities and environmental exposure which will affect mental and physical health of human being particularly those who are heavily involved with outdoor activities. Therefore, this is the first study in Malaysia and among few studies worldwide aims to explore the variation of air pollutants and noise exposure levels among traffic police officers and how this variation influence their level of mental and physical health.

METHODOLOGY

Study design, location and sampling method

This is a repetitive cross-sectional study which was conducted in Malaysia during three different season, Southwest Monsoon Season (Dry Season), Northeast Monsoon Season (Wet Season) and the Inter-monsoon Season. Kuala Lumpur was selected as urban area. Since the number of traffic police officers in each rural areas is small, eight districts in Pahang and Negeri Sembilan were selected to reach the desirable sample size. Random sampling method was applied in Kuala Lumpur from the total number of 500 officers. All traffic police officers in urban was invited to participate since there were only 4 to 20 total number of traffic police officers working in each district. One hundred and twenty seven participants recruited from rural areas and 201 from urban areas. The response rate was 49.70% ad declined to 42.38% (n=139) in the second follow up study and to 26.52% (n=87) in the third follow up study. The gap between each season was between three to 4 months. Survey in the first study which was conducted during Southwest Monsoon Season were distributed by researcher to police officers in designated study areas. Participants were given 2 weeks to complete the survey before returning them to the researcher in the safety box provided in each station. Each survey only took three minutes to be completed. The same survey were redistributed in the second and third study via mail to the same participants using contact detail provided in the first study. All personal information was kept confidential. Survey was self-administered and being translated to Malay and double check with back to back translation. The following sections describe about the domain contained in the survey.

Global Stress and Health

A single-item question on global stress was used to measure the level of stress for the past one week. The question was 'How was your general level of stress this week?' The answer was in in a form of Likert Scale, ranging from extremely low to extremely high. This question has acceptable 'test-retest reliability' (kappa and intra-class correlations between 0.66 and 0.74) [13]. A single-item question was also used to measure the perceived overall health of a person. The question is "In general would you say your health is...?" The scales use a five-point Likert scale (1 = excellent, 2 = very good, 3 = good, 4 = fair and 5 = poor). The GSRH has good test-retest reliability ($r = 0.74$, $p < 0.001$) and adequate validity, as established via correlation with scores in the General Health Survey (SF-12V) ($r = 0.56$, $p<0.001$) [14].

Perceived air pollution and noise levels

Questions on perceived air pollution and noise levels were adapted from physical demand scale of the Job Content Questionnaire [15]. The two questions were on toxic exposures which and the answer was in the form of four-point Likert Scale (1= not exposed, 2= I am exposed but it is a light problem, 3= I am exposed but it is a moderate problem and 4= I am exposed and it is a great problem). The JCQ is widely used and has acceptable internal consistency reliability ($\alpha = 0.73$ to 0.74) [15].

Measurement of air pollution and noise exposure levels

In this study, the level of particulate matters was measured as an indicator of air pollution exposure level among traffic police officers. Dustrak aerosol monitor was placed at significant road junctions in each study area for 2 ½ hours. The Dustrak aerosol displayed real-time concentration (mg/m^3). Measurement was taken twice in two consecutive normal working days to get the average. This duration of measurement was chosen as traffic police officers were exposed to road traffic around 2 ½ hours in each session for three times daily. The instrument was positioned 1 meter above the ground level using tripod as close as possible to the respondents who were controlling traffic. Sound level meter (SLM) was used to measure the noise level. It was also placed at the same spot with the Dustrak with the same duration. The unit of measurement is decibel A (dBA). Measurements were repeated in each season.

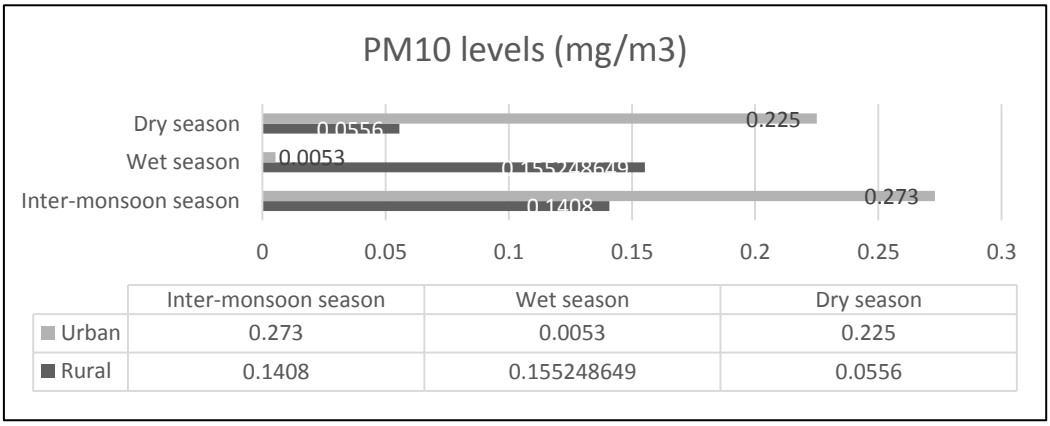
RESULTS

Socio-demographic characteristics of respondents

Most of the respondents were male (86.59%) with the average age of 38.84 years old. Majority of them possessed upper secondary school certificate as their highest level of education.

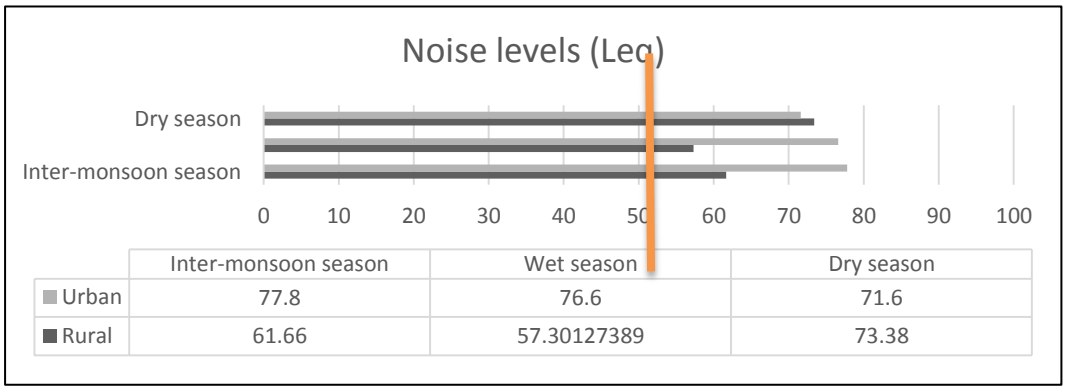
Levels of PM_{10} and noise exposure

The level of PM_{10} fluctuated across the three seasons for both urban and rural areas. The highest level of PM_{10} found in urban area was recorded during the Dry Season and the lowest level was recorded during the Wet Season. A slightly different pattern was found in rural areas where the PM_{10} was slightly higher during Inter-monsoon than Dry and the lowest level was found during Wet season. In urban areas, the level of PM_{10} found was higher than those of rural areas during the Dry and Inter-monsoon but lower during wet season. See figure 1. The level of noise showed the same fluctuation pattern as the level of PM_{10} at rural areas, but not in urban areas. In urban areas, the highest level of noise was recorded in the Inter-Monsoon season, and the lowest was in wet season. See Figure 2.



	Inter-monsoon season	Wet season	Dry season
Urban	0.273	0.0053	0.225
Rural	0.1408	0.155248649	0.0556

Figure 1. The level of PM_{10} exposure levels between seasons among respondents



	Inter-monsoon season	Wet season	Dry season
Urban	77.8	76.6	71.6
Rural	61.66	57.30127389	73.38

Figure 2. The level of noise exposure levels between seasons among respondents

Data from the perceived air pollution level and noise level showed the same fluctuation pattern as data from the onsite measurement. In contrast, the level of global stress and health was found highest during wet season, followed by inter-monsoon season and Dry season. See Table 1.

Table 1. Means of study variables in each season

	M (SD)					
	Southwest (Dry)		Northeast (Wet)		Inter	
Variables	Urban	Rural	Urban	Rural	Urban	Rural
Perceived air pollution	2.59 (0.93)	2.50 (0.85)	2.41 (0.66)	2.47 (0.67)	2.46 (0.77)	2.60 (0.78)
Measured PM_{10} (mg/m^3)	0.27 (-0.01)	0.14 (-0.05)	0.01(<0.01)	0.06 (-0.05)	0.23 (-0.04)	0.16 (-0.05)
Perceived noise level	2.41 (-0.94)	2.21 (-0.76)	2.40 (-0.68)	2.30 (-0.68)	2.11 (-0.63)	2.41 (-0.80)
Measured noise level (dB(A))	77.80 (-1.10)	61.66 (-1.26)	76.60 (-0.46)	57.30 (-2.4)	71.60 (-1.39)	73.38 (-1.65)
Global stress	3.89 (-1.37)	3.34 (-1.39)	4.40 (-0.92)	3.80 (-1.29)	4.01 (-0.92)	4.09 (-0.88)
Global health	2.97 (-0.80)	2.74 (-0.79)	3.74 (-0.54)	2.91 (-0.82)	3.42 (-0.71)	3.07 (-0.74)

Friedman's test was run to test the variation of each of study variables across three seasons. Results showed that seasonal variation had a significant effect on the level of global stress, global health, measured PM_{10}, measured noise ($\chi2(2) = 656$, $p< 0.01$) and perceived noise. Kendall tests were run to measure the strength of the variation of the variables. Measured noise levels showed perfect variation across seasons. Measured PM_{10} levels showed moderate variation and the others showed weak variation across seasons. See Table 2.

Table 2. Measures of difference in mean of selected variables between different seasons

	Friedman's test				
Variables	N	$\chi2$		*df*	Kendall's W
Global stress	88	17.88	***	2	0.10
Global health	90	12.75	***	2	0.07
Perceived air pollution level	91	3.47		2	NA
Perceived noise level	86	9.31	**	2	0.05
Measured PM_{10} levels	18	189.04	***	2	0.29
Measured noise levels	18	656	***	2	1

Note: NA = Not Applicable

Post-hoc Wilcoxon Signed Ranks tests were performed to identify the seasons in which the differences occurred in the level of global health, global stress, measured PM10 and noise levels as well as perceived air pollution and noise. Results showed that the global stress and global health scores were significantly different between the Dry Season and Wet Season and between the Dry and Inter-Monsoon season. The difference in measured PM_{10} and noise levels was significant between each season. Perceived noise was only significantly different between the Dry and Inter-monsoon. See Table 3.

Table 3. Pair-wise comparison for selected variables across different seasons

	Wilcoxon Signed Ranks (Z)					
Variables	Southwest (Dry) versus Northeast (Wet)		Southwest versus Inter		Northeast versus Inter	
Global stress	-3.61	***	-4.49	***	-1.61	
Global health	-3.28	***	-4.31	***	-0.01	
Perceived noise level	-1.92		-2.65	**	-1.84	
Measured PM_{10} levels	-11.38	***	-16.29	***	-11.37	***
Measured noise levels	-16.23	***	-16.17	***	-16.16	***

Spearman's Correlation analysis was conducted to see the correlation between study variables. The measured levels of PM_{10} and noise were consistently correlated with perceived global health in each season. The significant relationship was found between the measured levels of PM_{10} and noise with global stress in Dry and Wet Seasons. In Wet Season, higher levels of PM_{10} and noise was found to be correlated with lower level of global health and stress. In contrast, in Dry Season and Inter-season, higher levels of PM_{10} and noise was found correlated with higher level of global stress and health (poorer level of stress and health). See Table 4.

Table 4. Association between selected variables in three different seasons

		Dry season				Wet season				Inter-season			
		Global stress		Global health		Global stress2		Global health2		Global stress3		Global health3	
Dry season	PM_{10}	0.19	**	0.14	*								
	Noise	0.19	**	0.14	*								
	Perceived air pollution	0.22	**	0.13	*								
	Perceived noise	0.19	**	0.14	*								
Wet season	PM_{10}					-0.23	**	-0.45	**				
	Noise					-0.23	**	-0.45	**				
	Perceived air pollution					0.11	*	-0.02					
	Perceived noise					0.14	*	0.02					
Inter-season	PM_{10}									<0.01		0.13	*
	Noise									<0.01		0.13	*
	Perceived air pollution									0.29	**	0.12	*
	Perceived noise									0.23	**	0.12	*

DISCUSSION

The permissible occupational exposure level for PM_{10} is not provided by the WHO and the Department of Environment Malaysia. However, findings indicated that the level of PM_{10} exposed by the respondents working in urban areas during Dry season exceeded the permissible exposure level (PEL) suggested by the Ministry of the Environment Government of Japan [16]. As expected, these results was in contrary to the levels found in rural areas where all levels complied to the PEL. With reference to noise, the levels of noise recorded in urban exceeded the PEL proposed by the Department of Environment Malaysia [17] across all seasons. This level of PM_{10} fluctuated where highest level was found during Dry Season and lowest level was found during Wet Season. This finding is rather expected due the wash-out process of particulates by rainfall [2]. Similar pattern present for noise levels and the lowest level of noise was recorded during Inter-Season. It is unclear why noise level was recorded lower during rainy days than in Dry Season and lowest during Inter-Season. Since noise level is influenced by several other factors such as geometric spreading, atmospheric effects and surface effects, measurement of these variables might be able to explain this finding.

With regards to stress levels, respondents were found to be most stressful during Wet Season. Results also showed that during Dry Season, higher stress level was significantly correlated with higher PM_{10} level. In contrast, during Wet Season, higher stress level was correlated with lower level of PM_{10}. Due to the prolonged and frequent rain, police officers might have encountered several difficulties in performing their duties. For example, they were not being provided with appropriate attire to ease them in performing their duties. Zahari [18] claimed that they were being provided with low-quality raincoats which did not keep them from getting wet while controlling traffic on rainy days. Zahari [18] also described that on heavy rainy days, they had to work for longer hours due to massive traffic congestion. Several reasons may explain how heavy rains worsen traffic congestion. During heavy rain, roads are more slippery and visibility is reduced which will increase the road accident rate. Road accidents will disturbed the normal flow of traffic. Moreover, drivers drive slower during heavy rain as a precaution to avoid accidents which may aggravate the traffic congestion. The intermittent incidence of flash floods and falling trees may further exacerbate the difficulties of traffic police officers in doing their duties. The level of global health also showed the same trend with level of stress where poorest perceived health was recorded during Wet season. There is no established explanation on this relationship but finding of a recent research showed that high humidity during rainfall increase droplets size and transmission rate of viruses which is mediated by low temperature [19].

Findings of the presents study proposes that different approached needs to be adapted to maintain the health of respondents in different season. For example, during Dry Season, it is recommended that traffic police officers are supplied with suitable respiratory mask and earplug to protect their health but do not interfere with their work task. Instead, during Wet Season, traffic police officers is suggested to be provided with good quality raincoat to protect their body from detrimental effect of heavy rain exposure. Using PPE is often essential, but it is generally the least effective action in the hierarchy of control of occupational safety and health risks [20]. The findings of this study support recommendations to avoid permanent long duration outdoor duties and to assign more frequent duty rotation across departments in Traffic Branch. Prolonged shift for outdoor duties can be prevented by collaborating with other agencies including non-governmental agencies. For example, currently the Kuala Lumpur City Hall recruited more employees to assist in controlling road traffic in the city. The purpose of such collaboration is to compensate for staff shortage by allowing for more shift rotations and thus reducing workload and the duration of noise and air pollutant exposure. The burden of traffic police

officers will be reduced by encouraging people to use public transport in major city which will decrease the number of vehicles entering city.

CONCLUSION

This study lengthens the theoretical understanding of the complex interaction between environment and human psychological stress and health. This study confirmed that level of health and stress of respondents varied across seasons and related to the level of air pollution and noise in each season. However, other factors such as different work difficulties or activities during different season needs to be strongly considered in demonstrating about the relationship between environment and human health.

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