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Journal of Occupational Safety and Health

The Journal

- Aims to serve as a forum for the sharing of research findings and information across broad areas in Occupational Safety and Health.
- Publishes original research reports, topical article reviews, book reviews, case reports, short communications, invited editorial and letters to editor.
- Welcomes articles in Occupational Safety and Health related fields.

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Introducing the Journal of Occupational Safety and Health

The National Institute of Occupational Safety and Health (NIOSH) is delighted to announce the publication of Journal of Occupational Safety and Health.(JOSH).

JOSH is devoted to enhancing the knowledge and practice of occupational safety and health by widely disseminating research articles and applied studies of highest quality.

JOSH provides a solid base to bridge the issues and concerns related to occupational safety and health. JOSH offers scholarly, peer-reviewed articles, including correspondence, regular papers, articles and short reports, announcements and etc.

It is intended that this journal should serve the OSH community, practitioners, students and public while providing vital information for the promotion of workplace health and safety.

Apart from that JOSH aims:

- To promote debate and discussion on practical and theoretical aspects of OSH

- To encourage authors to comment critically on current OSH practices and discuss new concepts and emerging theories in OSH

- To inform OSH practitioners and students of current issues

JOSH is poised to become an essential resource in our efforts to promote and protect the safety and health of workers.

From the Editor in Chief

Workplace safety is a priority. Much needs to be done to encourage employees, employers and industries to put occupational safety and health at the top of their agenda. The most important thing is our commitment in taking action; our commitment to make the necessary changes to ensure that safety is at the forefront of everyone's thinking.

The Journal of Occupational Safety and Health, (JOSH) the first to be published in Malaysia, aims to boost awareness on safety and health in the workplace.

It is no longer sufficient to simply identifying the hazards and assessing the risks. We aim to increase understanding on the OSH management system. We aim to strengthen commitment to workplace safety and better working conditions. We believe these aims can be achieved through participations and involvement from every industry.

We hope the contents of the journal will be read and reviewed by a wider audience hence it will have a broader academic base, and there should be an increased cumulative experience to draw on for debate and comment within the journal.

It is our hope that the journal will benefit all readers, as our purpose is to serve the interest of everybody from all industries. Prime Focus will be on issues that are of direct relevance to our day-to-day practices.

I would personally like to take this opportunity to welcome all our readers and contributors to the first issue of the journal. I look forward to receive contributions from the OSH community in Malaysia and elsewhere for our next issues.

Ir. Hj. Rosli Bin Husin
Editor-in-chief

Cumulative Occupational Exposure Assessment for Mineral Dust Using Finnish Job-Exposure Matrix (FINJEM)

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Abstract

Mineral dust is classified by International Agency for Research on Cancer (IARC) as carcinogenic to humans because it is thought to cause lung cancer. Studies show strong associations between asbestos or other mineral dusts (OMD) exposure and respiratory health risk. The aim of the study was to examine the relationship between airflow obstruction (AFO) and cumulative occupational exposure to mineral dust, using the Finnish Job Exposure Matrix (FINJEM), in a population historically at high risk of lung cancer. The quantitative estimation of cumulative exposure to asbestos and OMD were calculated using the FINJEM from the data obtained at the baseline assessment in the Wythenshawe Respiratory Health Study (WRHS). The study was a population-based observational cohort study comprises all patients, aged 50- 75, registered with a General Practitioner (GP) practices in Wythenshawe District, Manchester. Among 257 study subjects who were assessed at baseline, 165 (64.2%) reported that they have been exposed to any occupational hazards, 56 (21.8% subcohort exposed) to asbestos and 42 (16.3% subcohort exposed) to OMD. There was a significant positive correlation between occupational exposure to OMD (Pearson correlation coefficient, $r = 0.47$, $p = 0.01$). They were 5 times higher risk to get airflow obstruction among those who have been exposed to low level of asbestos compared to non-exposed, after adjustment for gender, age and smoking (adjusted Odds Ratio (aOR) = 5.76, 95% Confidence Interval (CI) = 1.37 – 24.1). However, no significant association was found between level of exposure to OMD and airflow obstruction. It is suggested that workplace exposure to mineral dusts is sufficient to produce measurable airflow obstruction evidence of occupational respiratory ill-health. The findings from this study supports the FINJEM could be used in epidemiological study and a potential cost-effective exposure assessment particularly in examining the relationship between cumulative occupational exposures with respiratory ill-health.

Introduction

Occupational exposure is an important risk factor for respiratory ill-health, which includes lung cancer and Chronic Obstructive Pulmonary Diseases (COPD). Mineral dust is one of the most occupational respiratory toxins which can lead to occupational lung diseases. Mineral dust particularly asbestos is classified by IARC as carcinogenic to humans[1] because it is thought to cause lung cancer. Previous epidemiologic studies also show strong associations between asbestos or other mineral dusts (OMD) exposure and respiratory health risk[2,3,4]. The importance of asbestos and other mineral dusts for the development of respiratory symptoms and airflow obstruction has been well established as reported in population-based study[5].

Lung cancer is often accompanied by a variety of pathological changes within the adjacent lung. Recent studies have suggested a central role of chronic inflammation in the pathogenesis of both COPD and lung cancer. Exposure to occupational toxicants, includes mineral dusts; induces the inflammatory process which releases inflammatory cells leading to alveolar wall destruction and mucus hypersecretion. The shared mechanisms of chronic inflammation in both diseases, or in the progression of COPD increases the susceptibility for lung tumorigenesis up to 4.5-fold[6].

There is an increased risk of lung cancer associated with airway obstruction (lower percentage of forced expiratory volume in one second (FEV1) predicted). Higher risk of getting lung cancer was found among patients with severe airway obstruction, ie with an FEV1 $\leq$ 40% of predicted (OR, 95% CI = 9.6, 1.5-60.1)[7].

Occupational inhaled harmful particles have been known to play a role in several lung diseases, including chronic obstructive pulmonary disease (COPD) and lung cancer. The magnitude of the associations differs across studies. Differences in the sources and physical or chemical properties of asbestos or OMD exposure, level of exposure and the prevalence or airflow obstruction (AFO) among the studied population may contribute to heterogeneity in exposure-response relationship between studies. Large potential of misclassification of biologically significant exposure hinder detection of true elevated exposure-response relationships. The frequently lacking information on smoking habits in workers cohorts may lead to inaccurate risk estimates because of the prevailing role of smoking in respiratory ill-health patients[8].

Occupational exposure assessment in population-based study gives a major challenge due to the wide range of occupations in different types of industries involved. Previous studies investigated the association between occupational exposures and risk of developing respiratory ill-health which includes COPD and lung cancer proved to show the links by using the general population Job-Exposure Matrix (JEM)[5,9,10]. The Finnish Job-Exposure Matrix (FINJEM) is a tool yielding quantitative estimation of cumulative occupational exposure which represents a potentially cost-effective exposure assessment tool[11]. Moreover, it is applied since the previous exposure assessment at individual's level was not available in the study population. This paper is deemed to justify further analysis using the FINJEM-based method to study relationship between mineral dust exposure and airflow obstruction thus may assist in targeting a high risk population for lung cancer screening in the primary care setting.

The aim of the study was to examine the relationship between airflow obstruction (AFO) and cumulative occupational exposure to mineral dust, using the Finnish Job Exposure Matrix (FINJEM), in a population historically at high risk of lung cancer. To achieve these aims, the estimation of exposure to asbestos and other mineral dusts (OMD) were calculated using the Finnish Job-Exposure Matrix (FINJEM) from the data obtained at the baseline assessment in the Wythenshawe Respiratory Health Study (WRHS). The extent of exposure assessment thus looking at the association between airflow obstruction and occupational exposure were explored.

Methodology

Study population

Participants were part of the Wythenshawe Respiratory Health Study (WRHS) 2010, which looked for an early detection of respiratory ill-health in high risk populations. WRHS was a population-based observational cohort study comprises all patients, aged 50- 75, registered with a GP practices in Wythenshawe District, Manchester. Data on life-time occupational history was captured from the job questionnaire interviewed at the baseline study assessment. Occupation was initially coded according to the Standard Occupational Classification (2000)[33], using self-reported information on job title, type of work, type of company, period of employment and type of exposure. Exposure estimates were calculated based on occupation-specific estimates and the distribution of occupations within industries.

FINJEM was used to assign exposure information to individual workers. For each year of the total occupational history of each individual in the dataset, exposure was estimated using the time specific exposure information for occupational groups according to code of occupation (oCODE)[12,13,14]. All the information of every subjects were coded and calculated for the average exposure estimation in the excel database constructed for this study before transferred to SPSS database for descriptive and statistical tests analysis.

Statistical Analysis

Those workers exposed to inorganic mineral dust were analysed to look at the quantitative estimation of cumulative exposure of each subjects. Log transformed using the natural log function was carried out to create a new variable to reduce skewness for further analysis, for both quantitative data on cumulative exposure to asbestos and OMD. Pearson Chi-squared tests were used to test an association between different level of occupational exposure and outcome measure, airflow obstruction (AFO). Linear regression analysis was performed to assess the relationship between the forced expiratory volume in one second (FEV1 % predicted) and log-transformed cumulative occupational exposure to asbestos and OMD.

Multivariate analysis of airflow obstruction and the occupational exposure with potential confounders were then carried out using multiple linear regression (MLR) and the results are presented as Pearson correlation coefficient, r and the overall p -value. Statistical significance was assumed at $p < 0.05$.

Results

Among 257 study subjects who were seen and been interviewed at baseline, 165 (64.2%) reported that they have been exposed to any occupational hazards with different type of exposure to cancer-causing agents, namely dust, mist and/or fumes, mineral and/or chemicals and ionizing radiation or radioactive materials at some times in their working lives.

Occupational Exposure to Asbestos

With regards to asbestos exposure, 56 (21.8% subcohort exposed) subjects reported ever been exposed to asbestos. Based on FINJEM's code of occupation (aCODE), 21 occupational subgroups were found to be exposed to asbestos in this study. Most often reported jobs were metal smelting furnacemen, aCODE 630 subgroups (n = 27, 12.9%) followed by occupations in manufacturing, aCODE 759 (n = 25, 12.0%). Other subgroups are distributed in table 1.

Table 1. Code of occupation (aCODE) and the list of occupation with exposure to asbestos based on FINJEM for exposed study subjects

aCODE	List of occupations with asbestos exposure	n	%
400	Miners, shot firers etc.	5	2.4
490	Miners and quarrymen, nec	1	0.5
530	Railway engine and lorry drivers, steam engine firemen	8	3.8
630	Metal smelting furnacemen	27	12.9
651	Fitter-assemblers etc.	16	7.7
652	Machine and engine mechanics	4	1.9
653	Sheet metal workers	7	3.3
654	Plumbers	1	0.5
655	Welders and flame cutters	6	3.0
660	Electricians	12	5.7
663	Electronics and telecommunications Workmen	7	3.3
680	Painters, lacquerers and floor layers	9	4.3
690	Bricklayers, plasterers and tile setters	16	7.7
695	Insulation workers	7	3.3
697	Assisting building workers	19	9.1
698	Assisting construction workers, nec	15	7.2
699	Building occupations, nec	12	5.7
736	Refinery workers, other occupations in the chemical industry	1	0.5
759	Occupations in manufacturing, nec	25	12.0
770	Crane operators etc.	8	3.8
781	Warehousemen	3	1.4

Table 2 shows the summary of occupational exposure to asbestos among the study subjects. The mean of total years exposed was 24.1 ± 15.6 years with the mean cumulative exposure of 199.1 ± 342.2 f/cm^3. Average exposure ranged from 0.1 f/cm3 to 47.1 f/cm^3 with a mean of 10.0 ± 11.6 f/cm^3.

Occupational Exposure to Other Mineral Dusts (OMD)

When looking at the exposure to other mineral dusts (OMD), 42 (16.3% subcohort exposed) subjects reported ever been exposed to OMD. Based on FINJEM's code of occupation (aCODE), 12 occupational subgroups were found to be exposed to OMD in this study. Most often reported jobs were assisting construction workers, aCODE 698 subgroups (n = 34, 22.1%) followed by assisting building workers, aCODE 697 (n = 27, 17.5%) and occupations in smelting, metallurgical and foundry work, aCODE 639 (n = 25, 16.2%). Other occupational subgroups are distributed in table 3.

Table 4 shows the summary of occupational exposure to OMD among the study subjects. The mean of total years exposed was 21.9 ± 14.6 years with the mean cumulative exposure of 3888.5 ± 3711.6 mg/m^3. Average exposure ranged from 11.2 mg/m^3 to 370.0 mg/m^3, with a mean of 173.9 ± 91.6 mg/m^3.

Table 2. Summary of total years, cumulative exposure and average occupational exposure to asbestos

Occupational exposure to asbestos	Mean ± SD	Range
Total years (years)	24.1 ± 15.6	1.0 – 47.0
Cumulative Exposure (f/cm^3)	199.1 ± 342.2	2.4 – 2212.3
Average Exposure (f/cm^3)	10.0 ± 11.6	0.1 – 47.1

Table 3. Code of occupation (aCODE) and the list of occupation with exposure to other mineral dusts (OMD) based on FINJEM for exposed study subjects

aCODE	List of occupations with other mineral dusts (OMD) exposure	n	%
410	Well drilling and quarrying	3	2.0
630	Metal smelting furnacemen	19	12.3
639	Occupations in smelting, metallurgical and foundry work, nec	25	16.2
690	Bricklayers, plasterers and tile setters	17	11.0
695	Insulation workers	6	4.0
697	Assisting building workers	27	17.5
698	Assisting construction workers, nec	34	22.1
699	Building occupations, nec	3	1.9
719	Occupations related to glass, ceramic and fine earthenware, nec	2	1.3
736	Refinery workers, other occupations in the chemical industry	2	1.3
758	Concrete-mixer operators and cast concrete product workers	3	2.0
831	Charworkers	13	8.4

Table 4. Summary of total years, cumulative exposure and average occupational exposure to other mineral dusts (OMD)

Occupational exposure to other mineral dusts (OMD)	Mean ± SD	Range
Total years (years)	21.9 ± 14.6	1.0 – 47.0
Cumulative Exposure (mg/m³)	3888.5 ± 3711.6	240.0 – 13980.0
Average Exposure (mg/m³)	173.9 ± 91.6	11.2 – 370.0

Relationship Between Airflow Obstruction and Occupational Exposure to Asbestos

The relationship between airflow obstruction (percentage of FEV[1] predicted) with log average estimated asbestos exposure at the workplace was explored by using a multiple linear regression model with adjustment for confounding factors (age, sex, smoking status).

Multiple Linear Regression of Relationship Between Airflow Obstruction and Occupational Exposure to Asbestos

The scatterplot in figure 1 suggests a dose-response relationship between occupational exposure to asbestos and respiratory ill-health by looking at the airflow obstruction. The percentage of FEV[1] predicted levels decreased with an increase of asbestos exposure, however it was not statistically significant (Pearson correlation coefficient, r = 0.19, p = 0.26) (Figure 1).

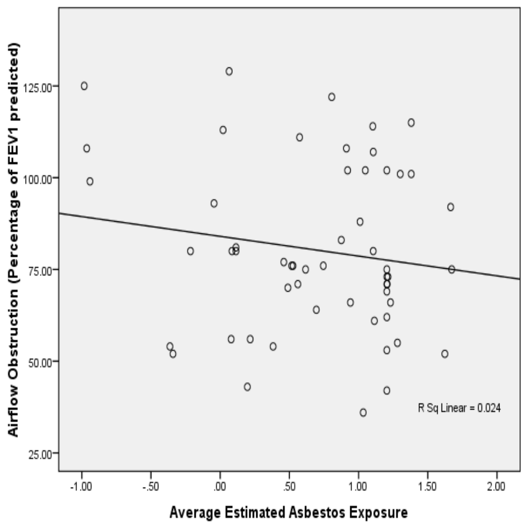

Figure 1. Relationship between airflow obstruction and occupational exposure to asbestos

Airflow Obstruction and Occupational Exposure to Asbestos Comparing Smokers and Non-smokers

Both figure 2 and 3 compare the relationship between airflow obstruction (percentage of FEV[1] predicted) and log-transformed cumulative occupational exposure to asbestos among smokers comparing to non-smokers. No significant difference were found in both groups; smokers (Pearson correlation coefficient, r = 0.11, p = 0.53) *vs*. non-smokers (r = 0.56, p = 0.15).

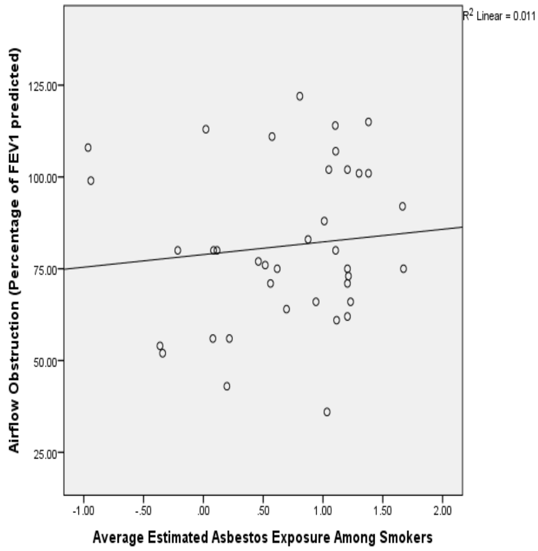

Figure 2. Relationship between airflow obstruction and occupational exposure to asbestos among smokers

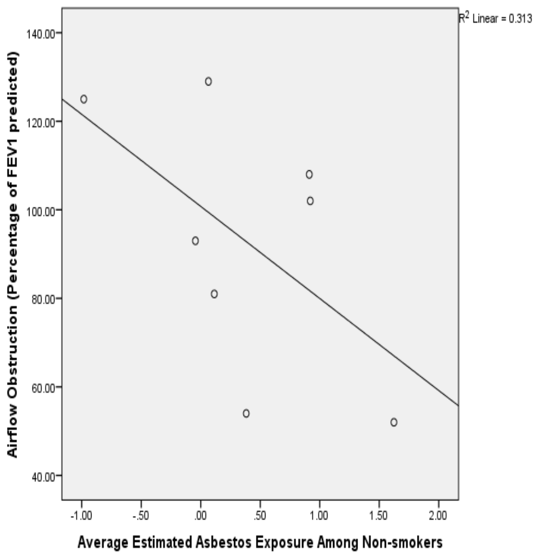

Figure 3. Relationship between airflow obstruction and occupational exposure to asbestos among non-smokers

Airflow Obstruction by Level of Exposure to Asbestos

To assess the risk of airflow obstruction at level of asbestos exposure, the data were further categorised into different level. Since there is no clear definition on different level of an elevated asbestos exposure, the data were ranked and divided into tertiles; (low, medium or high) according to an average of cumulative occupational asbestos exposure estimated in fibres per cubic centimetre of air (f/cm^3).

There was strong association found between level of exposure to asbestos and airflow obstruction. They were 4.40 times higher risk to get airflow obstruction compared to non exposed among those who have been exposed to low level of asbestos (95% CI = 1.53 – 12.6). After adjustment for gender, age and smoking, the risk became higher (aOR = 5.76, 95% CI = 1.37 – 24.1) (Table 5). No significant association was found between airflow obstruction and those who have been exposed to medium level. However, those who have been exposed to high level of asbestos was 6.45 times higher risk to get airflow obstruction compared to non exposed (95% CI = 1.54 – 27.0).

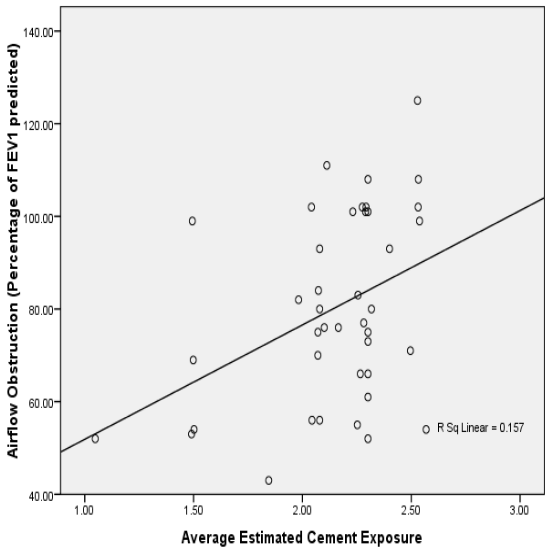

Figure 4. Relationship between airflow obstruction and occupational exposure to other mineral dusts (OMD)

Table 5. Airflow obstruction by level of exposure to asbestos

Level of exposure (N=228)	Airflow obstruction Yes/ No (% Yes)	Crude Odds Ratio (95% CI)[a]	Adjusted Odds Ratio (95% CI)[a]
Asbestos exposure			
No[b]	25/157 (13.7)	1*	1*
Low	7/ 10 (41.2)	4.40 (1.53 – 12.6)	5.76 (1.37 – 24.1)
Medium	6/ 11 (35.3)	3.43 (1.16 – 10.1)	3.71 (0.94 – 14.7)
High	6/ 6 (50.0)	6.28 (1.88 – 21.0)	6.45 (1.54 – 27.0)

[a]*Odds ratio is incidence of Airflow Obstruction (AFO) in level of exposure to asbestos group versus incidence in subjects in group*[b]
[d]*Adjusted odds ratio (aOR) for gender, age and smoking*
**significant association, p <0.05 obtained using chi-square test*

Relationship Between Airflow Obstruction and Occupational Exposure to Other Mineral Dusts (OMD)

The relationship between airflow obstruction (percentage of FEV^1 predicted) with log average estimated other mineral dusts (OMD) exposure at the workplace was explored by using a multiple linear regression model with adjustment for confounding factors (age, sex, smoking status).

Multiple Linear Regression of Relationship Between Airflow Obstruction and Occupational Exposure to Other Mineral Dusts (OMD)

The scatterplot in figure 4 suggests a dose-response relationship between occupational exposure to other mineral dusts (OMD) and respiratory ill-health by looking at the airflow obstruction.

Surprisingly, there was a significant positive correlation between occupational exposure to other mineral dusts (OMD). The percentage of FEV^1 predicted levels increased with an increase of OMD exposure, (Pearson correlation coefficient, r = 0.47, p = 0.01). The coefficient of determination, R^2 = 0.157; indicating that as OMD exposure increase, percentage of FEV^1 predicted also increase by 15.7%. (Figure 4)

Airflow Obstruction and Occupational Exposure to Other Mineral Dusts (OMD) Comparing Smokers and Non-smokers

Both figure 5 and 6 show the relationship between airflow obstruction (percentage of FEV^1 predicted) and log-transformed cumulative occupational exposure to OMD among smokers comparing to non-smokers. A weak relationship was found among smokers (Pearson correlation coefficient, r = 0.36, p = 0.06) but not among non-smokers (r = 0.68, *p* = 0.21).

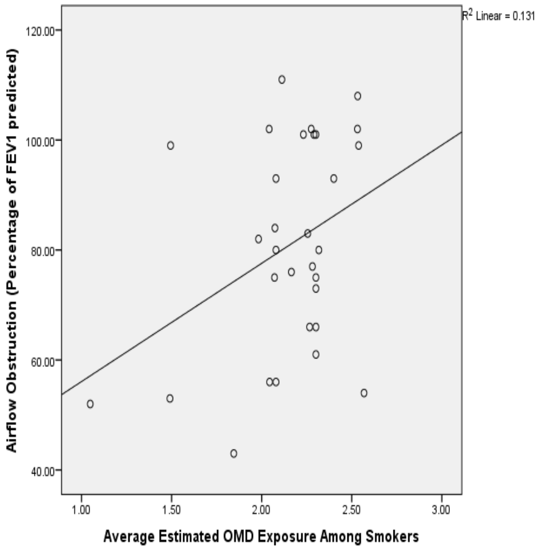

Figure 5. Relationship between airflow obstruction and occupational exposure to other mineral dust (OMD) among smokers

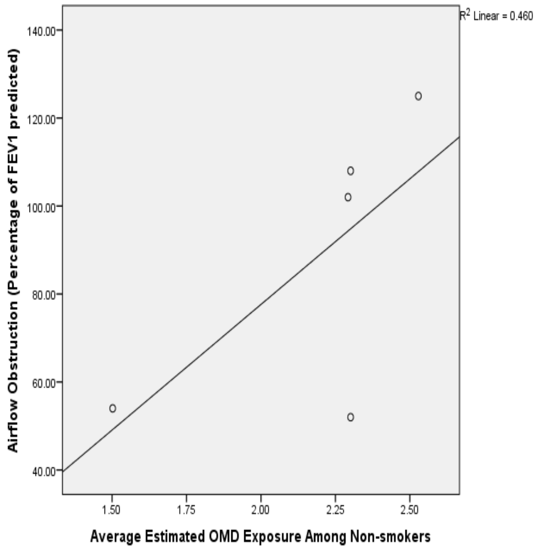

Figure 6. Relationship between airflow obstruction and occupational exposure to other mineral dust (OMD) among non-smokers

Airflow Obstruction by Level of Exposure to Other Mineral Dusts (OMD)

Similar to asbestos exposure, the data on other mineral dusts (OMD) exposure were further categorised into different level and been ranked and divided into tertiles; low, medium or high according to average of cumulative occupational OMD exposure estimated in milligram per cubic meter of air (mg/m^3).

They were 8 times higher risk to get airflow obstruction compared to non exposed among those who have been exposed to low level of other mineral dusts (OMD) (95% CI = 2.65 – 28.2), However, no significant association was found after adjustment for gender, age and smoking (Table 6).

Table 6. Airflow obstruction by level of exposure to other mineral dusts (OMD)

Level of exposure (N=228)	Airflow obstruction Yes/ No (% Yes)	Crude Odds Ratio (95% CI)[a]	Adjusted Odds Ratio (95% CI)[a]
OMD exposure			
No[b]	30/162 (15.6)	1*	1
Low	8/ 5 (61.5)	8.64 (2.65 – 28.2)	7.18 (1.70 – 30.3)
Medium	1/ 8 (11.1)	0.68 (0.08 – 5.60)	0.23 (0.02 – 2.34)
High	5/ 9 (35.7)	3.00 (0.94 – 9.57)	1.17 (0.27 – 5.15)

[a]*Odds ratio is incidence of Airflow Obstruction (AFO) in level of exposure to OMD group versus incidence in subjects in group*[b]
[d]*Adjusted odds ratio (aOR) for gender, age and smoking*
**significant association, p <0.05 obtained using chi-square test*

Discussion

This study was designed to investigate the relationship between airflow obstruction (AFO) and cumulative occupational exposure to mineral dusts, using the Finnish Job Exposure Matrix (FINJEM), in a population historically at high risk of lung cancer.

Based on our findings, occupation-specific exposure prevalence shows metal smelting furnacemen (aCODE 630) entailing highest exposure to asbestos and assisting construction workers (aCODE 698) involving highest exposure to other mineral dusts as given by FINJEM in the study population. The FINJEM was found to assign different cumulative exposures based on the occupational history in the population-based study. The advantages of using job-exposure matrix in estimating exposure for epidemiological studies has been described and discussed in previous studies[10,11,12,14]. Without having industrial hygiene measurement data with traditional exposure information in this study, estimated cumulative exposure could be measured to determine whether occupational exposure to asbestos and OMD are associated to an airflow obstruction. The same application using FINJEM have been used in previous studies looking at the chronic diseases and cumulative occupational exposure[15,16,17]. Our findings are consistent with the studies which show that metal smelting furnacemen and workers exposed to metal dusts and foundry fumes have a higher exposure to asbestos[18,19,20]. Similarly, assisting or people who involve in construction workers have a higher exposure to cement and other mineral dusts with provision of industrial hygiene measurement and personal sampling of those hazards at the workplace[21,22].

We found there were 21.8% subcohort exposed subjects reported ever been exposed to asbestos at some times in their working lives in this study. Similar findings on the prevalence of ever exposed to asbestos were found ranged from 13.1 to 24.5% in population-based studies conducted in France[23] and Central and Eastern European countries[4]. Asbestos has been used in so many ways since so many years and many workers in various occupation groups were involved and exposed to asbestos worldwide. It is consistent to the WHO report with estimation of 125 million people occupationally exposed to asbestos globally every year[24] and also the report by OSHA, NIOSH that estimated 1.3 million employees particularly in construction and general industry in the USA face significant asbestos exposure on the job[25].

There were 16.3% subcohort exposed subjects reported ever been exposed to other mineral dusts (OMD) in the study. The operational definition following to the Finnish Job-Exposure Matrix (FINJEM), exposure to other mineral dusts (OMD) was defined as occupational, inhalatory exposure to mineral dusts (eg, silicates, amorphous silica, stone, granular talc, clay, cement) except pure quartz, asbestos or manmade mineral fibres (MMMF)[12,13]. The limitation in estimating the exposure using FINJEM was we were unable to describe each type of defined OMD and only discuss on the finding found for a group of OMD. However, WHO global report and previous studies acknowledged the exposure to mineral dust is a significant occupational hazard in working populations worldwide, particularly among construction workers, concrete production and cement industry, etc, which need crucial monitoring on the exposure-related health problem as we were looked into in this study, the airflow obstruction among exposed subjects[26, 27].

A strong association was found in this study between estimated cumulative exposure to asbestos and airflow obstruction. They were 5 times higher risk to get airflow obstruction among those who have been exposed to low level of asbestos compared to non-exposed. The findings demonstrate a negative relationship between occupational exposure to asbestos and airflow obstruction. However it was not statistically significant and not influenced by cigarette smoking. These data were in agreement with several recently expressed opinions which showed exposure to asbestos was more strongly associated with decreased lung parameters in spirometry test, while smoking was one of major contributing factor to reduced lung parameters, particularly FEV^1/FVC[21,28]. A recent meta-analysis showed a similar opinion but stated that those reductions in lung parameters were found even in those workers without radiological changes[3].

Unlike some previous studies which did not support a causal role of exposure to asbestos in the development of airflow obstruction[28,30] presumably they focused on smokers and/or subjects with previously diagnosed asbestosis were included which possibly could contributed to the restrictive pattern in spirometry test. Although our study sample may not be representative of all people occupationally exposed to asbestos, the strength was the study population was selected from GP registered population in the study areas not merely for screening purposes.

In this study, we did not find any association between level of exposure to OMD and airflow obstruction after adjustment for gender, age and smoking. Those subjects who had an exposure to OMD did not have an increased risk of airflow obstruction and it was not in accordance with previous studies. A cohort study among male construction workers reported that occupational exposure to airborne inorganic dust (asbestos, man-made mineral fibres, dust from cement, concrete and quartz) increases mortality due to chronic obstructive pulmonary disease, even among never-smokers[26,30]. Another study also found similar finding and reported that cement workers seem to be at high risk of developing COPD caused by cumulative total dust exposure independent of smoking habit[30,31], which support the theory that dust-induced obstructive lung diseases and smoke-induced obstructive lung problem occur through similar mechanism.

The major strength of the present study is that we were able to measure the occupational exposure assessment in population-based study using the Finnish Job-Exposure Matrix (FINJEM)[5,8]. This retrospective assessment of the study subjects was based on their recorded occupations without any previous exposure assessment at individual's[21,32]. Similar advantages were reported by previous studies which had been using this FINJEM as an objective tool for exposure assessment data which cover major physical, chemical, microbiological, ergonomics and psychosocial factors.

Conclusion

It is suggested that workplace asbestos exposure sufficient to produce measurable airflow obstruction evidence of asbestos-related respiratory ill-health. Importantly, we established that the reduction in lung parameters and hence causing an airflow obstruction as one of risk for lung cancer were found among those workers who have been exposed to asbestos at workplace. This is relevant for medical surveillance among those high risk workers.

This study supports using FINJEM as a potentially cost-effective exposure assessment particularly in examining the relationship between airflow obstruction and cumulative occupational exposure to lung carcinogens particularly asbestos and OMD in a population historically at high risk of lung cancer. It could be used not only in epidemiological studies but also serves as an information tool for policy making, risk assessment and hazard surveillance.

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Issues On Occupational Safety And Health At Workplace Among Older Fishermen In Malaysia

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Abstract

The fisheries sector is an important sub-sector in Malaysia and plays a significant role in the national economy development. Fish is largely consumed by the population and the fishery industry is also a source of employment for those living in the coastal areas. However, sea fishing is a dangerous and risky occupation. Previous studies have shown that occupational accidents and injuries among fishermen are prevalent. Thus, this study was conducted to explore occupational safety issues among older fishermen in Malaysia. A total of 397 fishermen age 45 years and above in the states of Terengganu, Kedah and Perak were interviewed by trained enumerator using a questionnaire that focused on the safety problems at work and what are the causes of these problems. Data was analyzed using Statistical Program for Social Science (SPSS). Majority of respondents were male, Malay, married and had primary school education. The finding also showed that almost one-third of the respondents reported that they had experienced boat accidents mostly caused by bad weather. One-fifth of the respondents in this study have experienced accidents/physical injury in their workplace, with animal bites and being stung identified as the main contributor. Falls was reported by almost half of the respondents and slippery floor, strong waves and tripping were identified as the major causes. Few of the identified safety problems among these fishermen such as fall and animal bites are preventable and therefore future improvement can be designed to create a safer and better workplace for the fisheries sectors.

Keywords: Safety, older fishermen, workplace, Malaysia, hazard

Introduction

The fisheries sector (including marine capture fisheries, aquaculture, and inland fisheries) is an important sub-sector in Malaysia and plays a significant role in the national economy development. Fish is largely consumed by the population and the fishery industry is also a source of employment for those living in the coastal areas. Based on statistic by Department of Fisheries Malaysia (DOF) in 2010, this sector contributed 2,014,534.84 metric tonnes of fish production, valued at RM9,495.28 million, an increase of 8.86 percent and 10.02 percent both in quantity and in value compared to the year 2009. Furthermore, in the same year this sector contributed 1.3 percent to national Gross Domestic Product (GDP). Apart from that, it is also a source of employment, foreign exchange and a source of cheap animal protein supply for population in the country. Fish constitutes 60-70% of the national animal protein intake, with per caput consumption of 47.8 kg per year. The rate of demand for fish as the main source of protein is expected to increase from the current annual consumption of 630 000 tonnes to over 1 579 800 tonnes by 2010 (using an estimated population of 26 330 000 with a per caput consumption of 60 kg/year). In 1997, the fisheries sector provides employment for more than 79 000 fishermen (FAO, 2001). Although the development of the fisheries sector is growing well, the safety and health of workers should not be ignored or overlooked as accidents and injuries were also reported fishermen while at workplace. Department of Occupational Safety and Health Malaysia statistic has shown that the fisheries sector is the second highest reported cases of workplace accidents for the year 1994-2008, as shown in Figure 1 below. Therefore, this paper was to explore occupational safety issues at workplace especially among older fishermen in Malaysia, where its finding is hope to serve as reference value in planning programs and strategies for intervention in reducing injuries and accidents among older fisherman towards safe environment in workplace.

Table 1 Industrial Accidents Reported by Sectors, Malaysia, 1994-2008

Sectors	1994	1997	2000	2003	2006	2008
Agriculture, forestry and fishing	27,268	24,390	13,293	8,796	5,739	3,962
Mining and quarrying	1,406	763	643	736	541	368
Manufacturing	68,281	37,829	42,915	33,901	27,066	19,041
Utility	588	372	592	513	515	524
Construction	4,536	3,648	4,966	5,113	4,500	3,814
Trading	9,173	9,248	15,472	13,576	11,783	11,342
Transportation	4,437	3,276	4,800	4,142	3,653	3,305
Financial	592	367	7,293	6,195	5,386	718
Real estate, renting & business services	2,830	3,731	6,581	5,617	4,832	4,405
Total[1]	125,506	89,049	98,281	81,003	68,008	56,095

Note [1] Total accident reported include total commuting accidents

Source: Labor and Human Resources Statistics (various issues), Kuala Lumpur, Ministry of Human Resource

Literature review

Older workers

Previous studies have defined older workers in various terminology, for example according to Bourne (1982) and Warr (2000), the term of 'older workers' has been used to refer to employees aged 40 to those aged over 75 years old depending on the purpose and field of study. Thus, in the study of labor market participation, the term of 'older workers' typically refer to employees aged 50 or 55 years old and over. It was chosen because most of the countries, this age group have lower participation rates in the labor market (OECD, 2005). However, according to Muijnck and Zwinkels (2002), researchers who studied on older workers in an organization often place limits on the 40 or 45 of age and see the "old" as referring to knowledge skills and attitudes that have been obsolete. Therefore, it has been suggested that the use of "chronological age" may be an inadequate handling of the age factor in the work environment (Avolio et al., 1984; Settersten and Mayer, 1997; Sterns and Alexander, 1987; Sterns and Miklos, 1995; Wolf et al., 1995). However, in this study we used 45 years old as the cut off as defined by WHO for older workers in Malaysia.

Safety and Health Issues among Older Fishermen

Many previous studies highlighted that sea fishing, which is a part of fisheries sector, is hazardous and risky occupation (Jin, Kite-Powell and Talley, 2001; Morel, Amalberti and Chauvin, 2008; Murray, Fitzpatrick and O'Connell, 1997; Lise, Henrik & Olaf, 2008). Finding also showed that majority of hospitalized injuries among Alaska commercial fishermen are causes by machinery (Jennifer and Chelsea, 2008). As fisherman, working on wet, slippery, handling heavy equipment, cables and ropes are a familiar situation. Furthermore, inclement weather and the poisonous spines of some fish are considered natural hazards (Sprent, 1988). Falls were also reported as a major contributor to commercial fishing fatalities among Alaska fisherman. The most common circumstances associated with falling overboard were working with fishing gear, being alone on deck, losing balance or slipping, heavy weather, gear entanglement, and alcohol consumption (Devin and Jennifer, 2007). This problem also evident internationally where Abraham (2001) reported that falls overboard in the U.S represent 25% of all fishing fatalities, compared to 27% in Norway, Denmark (30%), Ireland (20%) and Iceland (33%).

Materials and methodology

Participants

Data was obtained from a cross-sectional study entitled 'Workplace Safety and Health among Older Workers: Programs and Strategies for Intervention' conducted between the years 2009-2011 by the Institute of Gerontology, Universiti Putra Malaysia. A total of 397 sea fisherman aged 45 years and above from the states of Terengganu, Kedah and Perak in Peninsular Malaysia voluntarily participated this study. Participants were identified through Persatuan Nelayan (Fisherman Welfare Association) from every districts/areas in that states. Each district/area provided around 25-30 sea fishermen to be as respondents in this study.

Instruments

Respondents were interviewed face-to-face by enumerator using questionnaires that were developed based on inputs and information given by fishermen from an earlier Focus Group Discussion (FGD). This FGD was chosen as a guideline in the qualitative method where complex themes can be selected to be the topic for discussion and analysis. FGD is a good approach to gather people from similar backgrounds or experiences to discuss a specific topic of interest. The strength of FGD relies on allowing the participants to agree or disagree with each other so that it provides an insight idea on how a group thinks about an issue, coordinate the range of opinion and ideas, and make judgement on the inconsistencies and variations that exists in a particular community in terms of beliefs and their experiences and practices (Krueger and Casey, 2009; Morgan, 1997; Stewart, Shamdasani and Rook, 2007). In addition to details of demographic background and fishing background, the questionnaire also included several aspects related to safety issues at workplace such as:

i) Safety problems at workplace: the respondents indicated type of problems that they were faced at workplace whether boat accident, accident/physical injury caused by machinery, equipment, building infrastructure and public facilities, chemical, animal or others, fall and etc.

ii) Factor causing safety problems at workplace: this consisted question on how safety problems are happened whether causing by shallow/narrow river confluence, beacon lamp not function/available, jetty/port is busy or congested, bad weather, not wearing/using personal protection equipment, slippery floor, tripping over equipment, or machine while working and etc.

Analysis

Data was analyzed using SPSS (Statistical Programme for Social Sciences). Level of significance was set at $p<0.05$ (two-tailed). Descriptive analysis was performed to identify frequency, percentage, mean and standard deviation on background demographic items (gender, race, age, level of education, marital status, household size, years fishing and monthly income) and safety issues at workplace.

Result

Table 2 details the demographic background of the respondents. It shows that most of respondents were male (99.7%), Malay (90.2%), average age was 56.43 years old (SD=7.748), primary school education (65.2%), married (90.4%) and with an average household and monthly income size of 5.4 (SD=2.573) and RM884.15 (SD=RM588.781) respectively.

In response to the questions about safety issues at workplace, Table 3 showed that 27.7 percent of respondents reported having experience boat accident during working, with reasons such as bad weather (15.4%), poor boat condition (13.9%), beacon lamp not working/available (7.3%), busy and congested jetty/port (3.3%), shallow/narrow river confluence (3.0%) and confusion of similar colour signal light for all situations (1.3%).

Finding also showed that accident/physical injury is another issue reported by respondent at workplace, with possible causes due to animals (15.1%), equipment (4.3%), machinery (3.3%), chemical (0.5%) and building infrastructure or public facilities (0.3%). Several factors were identified contributing to those problems above, which mostly by animals bite and sting (11.6%), respondents were not wearing/using personal protection equipment (5.0%), no personal protection equipment available/provided (4.3%), using equipment/machinery/ chemical without caution (3.3%), lack of knowledge/

Table 2 Demographic background of respondents

Items	N	%	Mean	SD
Gender				
i. Male	396	99.7		
ii. Female	1	0.3		
Race				
i. Malay	358	90.2		
ii. Chinese	39	9.8		
iii. Indian	-	-		
iv. Others	-	-		
Age	397	100	56.43	7.748
Level of education				
i. Never been school	25	6.3		
ii. Primary education	259	65.2		
iii. Lower secondary education	73	18.4		
iv. Upper secondary education	33	8.3		
v. Higher education	5	1.3		
vi. Others	2	0.5		
Marital status				
i. Never married	18	4.5		
ii. Now married	359	90.4		
iii. Divorced/separated	5	1.3		
iv. Widowed	15	3.8		
Household size			5.4	2.573
Monthly income			884.15	588.781

exposure on aspects of safety at workplace (3.0%) and unsatisfactory/damage of machinery/equipment/building infrastructure and public facilities (1.5%). Respondents also reported experience problem on fall (50.6%) during work, which mostly causes by slippery floor (44.3%), strong wave (41.3%) and tripping over equipment/ machine (20.7%).

Discussion

Even though the analysis only focused on problems and factors that contributed to safety issues at workplace among fisherman, finding is helpful in given us the scenario of work environment faced by fisherman in their daily work. Almost one-third of respondents reported

Table 3 Safety problems and factors causing safety problems faced by respondents at workplace

Safety problems	N	%	Factors causing safety problems	N	%
Boat accident			Shallow/narrow river confluence		
i. Yes	110	27.7	i. Yes	12	3.0
ii. No	287	72.3	ii. No	385	97.0
			Busy and congested jetty/port		
			i. Yes	13	3.3
			ii. No	384	96.7
			Beacon lamp not working/available		
			i. Yes	29	7.3
			ii. No	368	92.7
			Poor boat condition (damage, too old)		
			i. Yes	55	13.9
			ii. No	342	86.1
			Bad weather		
			i. Yes	61	15.4
			ii. No	336	84.6
			Confusion of similar colour signal light for all situations		
			i. Yes	5	1.3
			ii. No	392	98.7
Accident/physical injury caused by machinery			Not wearing/using personal protection equipment		
i. Yes	13	3.3	i. Yes	20	5.0
ii. No	384	96.7	ii. No	377	95.0
Accident/physical injury caused by equipment			No personal protection equipment available/provided		
i. Yes	17	4.3	i. Yes	17	4.3
ii. No	380	95.7	ii. No	380	95.7
Accident/physical injury caused by building/public facilities			Using equipment/machinery/chemical without caution		
i. Yes	1	0.3	i. Yes	13	3.3
ii. No	396	99.7	ii. No	384	96.7
Accident/physical injury caused by chemical			Unsatisfactory/damage of machinery/equipment personal protection equipment/ building infrastructure and public facilities		
i. Yes	2	0.5	i. Yes	6	1.5
ii. No	395	99.5	ii. No	391	98.5
Accident/physical injury caused by animal			Lack of knowledge/exposure on aspects of safety at workplace		
i. Yes	60	15.1	i. Yes	12	3.0
ii. No	337	84.9	ii. No	385	97.0
			Animals bite or sting		
			i. Yes	46	11.6
			ii. No	351	88.4
Fall			Strong wave		
i. Yes	201	50.6	i. Yes	164	41.3
ii. No	196	49.4	ii. No	233	58.7
			Slippery floor		
			i. Yes	176	44.3
			ii. No	221	55.7
			Tripping over equipment/machine		
			i. Yes	82	20.7
			ii. No	315	79.3

that they have experienced boat accident, which mostly caused by bad weather. It is not surprising because Malaysia is a country that is of equatorial climate, giving it a warm and wet weather due to its proximity to the equator. On an average, Malaysia receives about 6 hours of sunshine each day with cloud formations occasionally leading to rainfall. There are two monsoon winds that influence the rainfall at different intervals of the year. The Southwest Monsoon usually occurs between May till September, bringing rainfall to the western side of Peninsular Malaysia. On the other hand, the Northeast Monsoon starts from November and lasts till March to areas on the east side of Peninsular Malaysia. As this monsoon wind is particularly strong, it often brings heavy rain to the west side of Peninsular Malaysia. This finding is similar to Yue, Roland and Casey (2005) where weather condition contributed fishing boat incidents in Atlantic Canada.

Accident/physical injury is common problem among fisherman (Norrish & Cryer, 1990). Therefore, it shows that almost one-fifth of respondents in this study experienced this problem in their workplace, where animals bite and sting were identified as the main contributor to this problem followed by lack awareness among respondents in using personal protection equipment when working. This finding is similar with other studies, where commercial fishermen are exposed to specific hazards including marine animals as well as more widespread hazards such as mechanical equipment, fatigue and stress (Holland, 1969; Schilling, 1971; Barss, 1985; Jeays, 1987; Dutkiewicz, Jablonski, & Olenchock, 1988; Sutherland and Flin, 1989). In this study, falls was reported to affect the highest number of respondents, approximately almost half of respondents. Slippery floor was identified the major contributor to this problem. For fishermen, work capacity is very largely determined by the condition of the legs; therefore, leg injury can be a serious matter in commercial fishing (Olaf, 2000). Therefore, it is important for every fisherman to avoid any hazards that can lead to risk of falling during working.

Conclusion

Safety is a critical issue that needs to give fully attention by everyone, including at workplace. Although the current Marine Act or the Fisheries Ordinance, 1985 (Act 317) in Malaysia do not include legal aspects of the fishermen mainly in the aspects of occupational safety and health in the workplace, but it also needs to be given serious attention. Interventions and guideline related to safety and health at workplace for fishermen should be developed and provided. By identifying problems and factors that contributed to this issue, it will help us in future to improve workplace to become more safe and comfortable for older workers.

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Research Article

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Occupational Heat Stress And Physiology Parameters Of Male Workers In A Steel Plant Factory At Pasir Gudang, Johor

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Abstract

A cross-sectional study was conducted in a steel plant in Pasir Gudang, Johor. The main objective of this study was to determine heat stress and its effect on physiological changes such as body core temperature, blood pressure, pulse rate and heart rate recovery among male workers steel plant. A total of 60 workers from steel plant were selected. Physiological parameters such as body core temperature, blood pressure, pulse rate and heart rate recovery were measured by standard and systematic technique. Environmental parameter such as WBGT(in) and WBGT(out) was measured by using QUESTEMP° 34 Thermal Environment and meanwhile for air velocity was measured by using Velocicheck Model TSI 8850. Self-administered questionnaire was used to determine respondents' socio-economic background, daily activities and status of health. The range of body core temperature was between 36.0°C to 37.6°C. The range of systolic blood pressure and diastolic blood pressure was between 100 to 120 mmHg and 60 to 90mmHg. The mean for WBGT (in) is 29.1°C and the mean for air velocity is 0.23m/s. The One-Way ANOVA shows that there were no significant differences for heat stress index between before, 2 hours after and 8 hours after work. The Pearson Correlation Test showed that there are weak correlation between heat stress index and body core temperature and also body core temperature and blood pressure. There are strong significant relationship ($p<0.05$) between body core temperature (8 hours after work) and pulse rate (8 hours after work). This study revealed that workers should be working based on 50% work and 50% rest hourly because they are at the risk of heat stress.

Keywords: Heat stress, Physiological Changes, WBGT(in)

Introduction

The American Conference of Government Industrial Hygienists (ACGIH, 2001) defines heat stress as "the net heat load to which a worker may be exposed" Heat strain is defined as "the overall physiological response resulting from heat stress". This study aims to assess the specificity of heat and its effects on physiological changes such as core body temperature, blood pressure, pulse rate and pulse recovery rate among male workers at a steel plant. Heat illness is the result of excessive strain on the body and is a highly variables human response to heat stress. ACGIH (2001) has identified the thresholds for illness in terms of core body temperature. While these thresholds may be exceeded by some individuals without ill effect, the application of these guidelines will ensure protection of workers and teams, as a single illness affects the safety of the workers who are exposed to overheating environment. The threshold level of core temperature associated with loss of judgment and reaction time is 38°C. At a core temperature of 38.6°C and above, physical heat strain has begun and, if not treated, will progress to acute heat illness and eventually the life-threatening condition of heat stroke (ACGIH, 2001).

Assertive heat is a hazard that increases the risk of interference environment firmness heat. The most significant physiological response shown is an increase in body temperature, pulse rate and sweating a lot (Lucas et al, 2014). The severity of heat occurs due to three factors: working conditions, workload and clothing (Chen et al, 2014). The rate of heat exchange between the skin and the environment depends on the conduction process, convection, radiation and evaporation (Crider et al, 2014). The working environment of heat will increase the risk of heat stress among workers, especially in the workplace that has poor ventilation and low humidity (Dang and Dowell, 2014).

A study in Malaysia found that the average comfortable temperature for the normal population in Malaysia is between 24.0°C to 28.0°C and an ambient temperature of above 28.0°C raises the risk of heat stress (Mohd Peter and Shanmugavelu, 1999). The human body can compensate for the temperature rose to 42.0°C and decreased to 32.0°C before the physiological functions of the body and damage occurs (Pardo, 1998). Assessment and control of thermal stress requires knowledge of the physical components of the environment such as temperature or humidity affects the heat exchange between human beings and the environment (Logan and Bernard, 1999).

Methodology

This cross-sectional study was conducted over three months. Data was collected at one of the multi-national steel plant site in Pasir Gudang, Johor. Purposive sampling was used based on the inclusion criteria set out in this study which were, worker who were exposed to heat for minimum 8 hours or more at work, working experience more than 1 year and not suffering from any diseases such as heart disease or hypertension. Total of 60 workers were selected in this study.

A questionnaire was used to determine socio-demographic information, daily activities and health status of the respondents. Face to face interviews with respondents were conducted using a same technique and method. Environmental heat conditions during working activities were monitored using QUESTEMPº34 digital instruments to record ambient air temperature, natural wet bulb temperature, radiant (globe) temperature, and air speed. These data were used to calculate a WBGT(in) heat index value for the exposure. WBGT(in) for low radiant heat exposures such as in steel plant is calculated as;

WBGT(in) = 0.7 Tnwb + 0.3 Tglobe

Where, Tnwb = natural wet bulb temperature

Tglobe = globe temperature

(NIOSH, 1986; ISO, 1989)

The Time Weighted Average (TWA) of occupational workplace areas was taken 3 times; before work, 2 hours of work and completion of work task. Wind velocity was measured by using wind speed measurements model Velocicheck TSI 8850 and the average reading for the whole 8 hours of work taken.

Body core temperature measurements were taken using Instant Ear Thermometer Model MC509. The blood pressure of respondent determined manually using a Sphygmomanometer Model Riester. Heart rate is taken by measuring the radial artery pulse in a minute (60 seconds). In the general population, sustained heart-rate levels associated with excessive heat strain vary between 180 beats per minute (bpm) less the person's age (ACGIH, 2001; NIOSH, 1986). Because of the variety of ages and cardiovascular conditioning found in the population of steel plant workers and the variety of often physically demanding activities they performed, it was difficult to assess heat strain by means of peak heart rate alone. Another means of assessing heat strain is through the recovery heart rate. The reference sets a limit of 110 bpm for a recovery time of 1 minute (ACGIH, 2001; NIOSH, 1986). Another means of assessing recovery is to compare recovery heart rate to fully resting heart rate. Recovery heart rate was taken as the heart rate 2.5 minutes after resting (P^3) and was compared to the pulse rate of workers in the first 30 seconds (P^1), while the subject was wearing an apparatus but before activities were begun. A rise in this resting rate indicates accumulated strain in the person. Reading of core body temperature, blood pressure and pulse rate was taken 3 times; before work, 2 hours of work and completion of work task.

Pre-testing of questionnaire was conducted on 10% of respondents in the steel plant. QUESTEMP °34 and Velocicheck TSI Model 8850 was calibrated every day before the observations were made. Calibration is carried out based on the Standard Operation Procedure (SOP) stated in the instrument manual.

All data obtained from the measurements and questionnaires were analyzed using SPSS for Windows Version 19.1. These data were tested using descriptive methods to determine the number of respondents, frequency, mean, range, and standard deviation of each variable ambient temperature, wind velocity, temperature and weight, blood pressure, pulse rate, pulse rate and recovery. Descriptive test used for the determination of respondent socio-demographic status information. One-way ANOVA and Pearson correlation test was used to determine differences and relationships.

Results

Table 1 shows the socio-demographic information of the respondents. Mean age of the 60 respondents were 32.4years. Mean height and weight of respondents, respectively, are 1.71m and 68.52kg. The mean body mass index is 23.18kg/m2, the mean number of years of formal education was 11.2 years and the mean total household income is RM 1758.30. The majority of the respondents were Malays, 52 (86.6%), and Indians (4 respondents) and others (4 respondents), none workers are Chinese. Fifty one respondents (85%) are married and 9 (15%) are not married. The majority of respondents had an education level of high school with the highest number of 43 respondents (71.6%).

Table 2 shows the temperature WBGT(in) and wind velocity in the Electrical Arc Furnace (EAF), Ladle Furnace (LF) and Continuous Casting Machine (CCM). The range of WBGT (in) in the three working areas (EAF, LF and CCM) of the steel plant is 27.9°C to 34.9°C and the wind velocity range is between 0.17 to 0.29m/s. Table 3 shows the mean and range of body core

Table 1: Socio-demography of respondents

Variables	Range	Mean ± S.D
Age (years)	23 – 45	32.4 ± 5.26
Height (m)	1.60 – 1.79	1.71 ± 0.05
Weight (kg)	52.0 – 76.4	68.52 ± 6.15
Body Mass Index (kg/m²)	20.31– 24.84	23.18 ± 1.30
Years of formal education (years)	6 – 17	11.2 ± 2.09
Household income (RM)	1125 – 4210	1758.3 ± 629.44
Ethnics	**Frequency**	**Percentage (%)**
Malays	52	86.6
Indian	4	6.7
Others	4	6.7
Marital Status	**Frequency**	**Percentage (%)**
Married	51	85
Not Married	9	15
Educational Level	**Frequency**	**Percentage (%)**
Primary	1	1.7
Secondary	43	71.6
Diploma	12	20.0
Degree	4	6.7

N=60

Table 2: Temperature of WBGT(in) and wind speed at working area.

Variables	Areas	Range	Mean ± S.D
WBGT (in)°C	EAF	31.1-34.9	32.7 ± 1.2
	LF	29.8-33.4	31.4 ± 0.94
	CCM	27.9-32.8	29.3 ± 1.14
Average WBGT(in)°C		27.9-34.9	31.1
Wind speed (m/s)	EAF	0.17-0.22	0.19 ± 0.02
	LF	0.18-0.27	0.23 ± 0.02
	CCM	0.24-0.29	0.27 ± 0.01
Average wind speed (m/s)		0.17-0.29	0.23

N=60

temperature, blood pressure, pulse rate and pulse rate of recovery. The body core temperature before work, 2 hours of the work and the complete 8 hours work ranges from 36.0°C to 37.6°C. Range of systolic and diastolic blood pressure is between 100 and 120 mmHg and 60 to 90 mmHg. Pulse rate pulse range is 64 to 84 per minute. The difference recovery rate of pulse P1 and P3 are 0 to 6 pulses.

Figure 1 shows the acute health complaints due to thermal stress since starting work in factory. Thirty nine respondents (65%) experienced fatigue, 20 (33.3%) had irregular movement, 27 (45%) had headache, 10 (16.7%) complained of nausea, 9 (15%) anorexia and 21 (35%) experienced muscle spasms. Meanwhile, there are 2 respondents (3.3%) who had experience suffering from fainting during the first month they started working in this factory.

The results of comparative One-way ANOVA on level of WBGT(in) between areas of work EAF, LF and CCM showed there is no significant differences. This means that employees who work in these three areas are exposed to the same risk of indoor heat temperature. In Table 4 of the Pearson correlation test showed there is no significant correlation between the parameters of heat stress index with all physiological parameters.

Table 5 shows the correlation between body core temperature and blood pressure, pulse rate and pulse recovery. This test showed no significant relationship

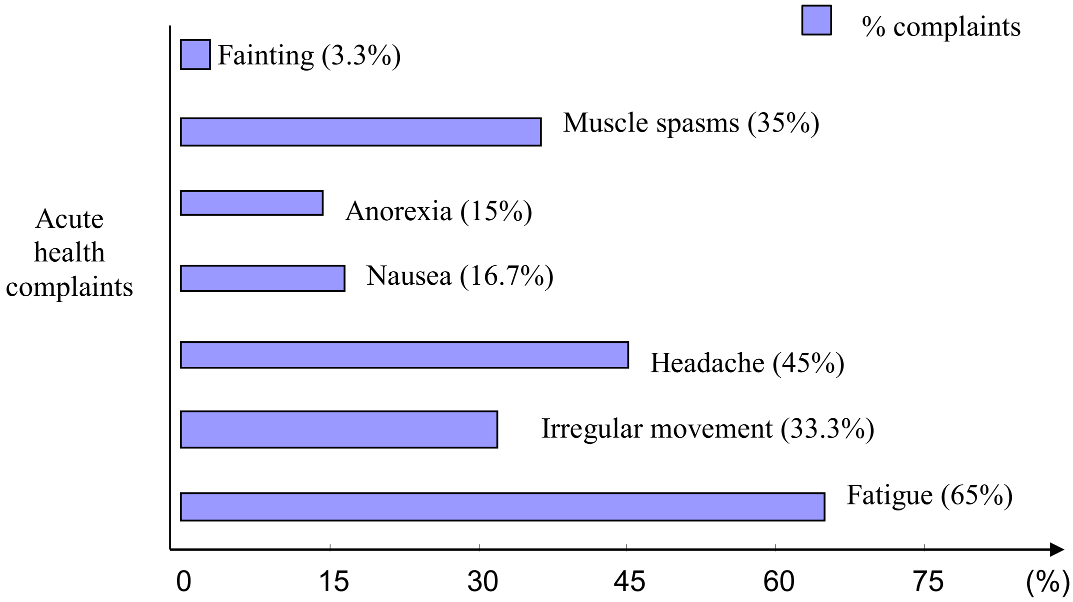

Figure 1: Distributions of acute health complaint related to heat stress

Table 3: Descriptive information of body core temperature, blood pressure, heart rate and recovery heart rate

Body core temperature (°C)	Range	Mean ± S.D
Before work	36.0 – 37.2	36.53 ± 0.35
2 hours work	36.3 – 37.6	36.97 ± 0.34
After work	36.1 – 37.5	36.78 ± 0.34
Blood pressure (mmHg)		
Before work (systolic/diastolic)	100/60 – 120/90	
2 hours work (systolic/diastolic)	100/60 – 130/95	
After work (systolic/diastolic)	100/60 – 130/95	
Heart rate per minute		
Before work	64 – 84	74.27 ± 5.32
2 hours work	66 – 84	74.37 ± 4.80
After work	66 – 84	74.50 ± 5.03
Heart rate recovery		
Difference of P_3 and P_1	0 - 6	0.40 ± 1.01

N=60

between body core temperature and blood pressure and pulse rate of recovery. There is only a significant relationship between body core temperature (after complete 8 hours of work) with pulse rate (after complete 8 hours of work), with p=0.042.

Discussion

The WBGT(in) in the EAF is higher than the LF and CCM area. This is because in the EAF is the first process there is iron smelting in a furnace with a high temperature of 1000°C to 1650°C. The mean overall WBGT(in) was 31.1°C. Predicted correction value of WBGT(in) heat stress exposure based on Clothes Adjusted Corrections Index of WBGT(in) produced by ACGIH (2003). Correction value is -2°C adjusted for cotton types clothes, therefore the final value WBGT(in) of heat stress exposure is 29.1°C. Clothing is important in determining heat stress yet little guidance is provided in the standard. The use of absorbing sweat clothes constant factor in the WBGT(in) equation would enhance validity for work in the sun. Use of the proposed 'clothed WBGT(in)' would enhance validity and should be further investigated (Parsons, 2006).

The mean wind velocity at the steel plant was 0.23m/s, while the limit for thermal comfort is determined by wind velocity is 0.25m/s (ACGIH, 2003). Working space is limited, narrow and the weather is one of the significant factors that lead to low wind velocity (Bisesi

Table 4: Pearson correlation of Heat Stress Index WBGT(in) with physiological parameters.

Body core temperature (°C)	r value	p value
Before work	0.224	0.371
2 hours work	0.141	0.577
After work	0.283	0.256
Blood pressure (mmHg)		
Before work (systolic/diastolic)	0.292	0.239
2 hours work (systolic/diastolic)	0.207	0.409
After work (systolic/diastolic)	0.346	0.159
Heart rate per minute		
Before work	-0.130	0.608
2 hours work	-0.141	0.577
After work	-0.061	0.809
Heart rate recovery		
P_1: heart rate for 30 seconds	-0.044	0.861
P_3: heart rate for 2.5 minutes	-0.190	0.450

N=60

Table 5: Pearson correlation of Body Core Temperature (°C) with physiological parameters.

Blood pressure (mmHg)		
Before work (systolic/diastolic)	0.066	0.615
2 hours work (systolic/diastolic)	0.080	0.542
After work (systolic/diastolic)	0.007	0.959
Heart rate per minute		
Before work	0.201	0.123
2 hours work	0.229	0.079
After work	0.264	0.042*
Heart rate recovery		
P_1: heart rate for 30 seconds	0.201	0.123
P_3: heart rate for 2.5 minutes	0.225	0.084

N=60
* Significant at $p \leq 0.05$

and Kohn, 1997). The results showed that the EAF has a low wind velocity than prescribed by ACGIH (2003) compared with the LF and CCM areas. This proves the workers in the EAF having most discomfort thermal compare to workers in the LF and CCM areas.

Differences in the rate of recovery pulse shows the difference of P^1 and P^3 were less than 10. According to ACGIH (2001), this difference shows high heat stress experience by workers and need prolong recovery. Duration of workers exposed to heat should be reduced based on ACGIH (2003) guideline. The study found there is no significant correlation between the Heat Stress Index with body core temperature of the workers. There are studies concerning the response of extreme temperatures on thermoregulatory showed no significant increase of body core temperature during extreme exercise (Montain et al, 2000).

Results shows there is a significant correlation between body core temperatures and pulse rate fully after 8 hours working periods. Pulse rate is influenced by the reaction and movement temperature, the heart beat and the workplace environment. An increase in the body's core temperature will result in the need VO^{2max} (maximum volume of oxygen) will increase. Requirements VO2max is a measure of the total volume that needs to be supplied to the muscles to function effectively. This causes the heart to pump harder and pulse will be increased (Minard, 1973).

Reference guideline produce by ACGIH (2001), determine the working posture of the respondent to accomplish the task in the standing mode and the average energy used for one hour is 36 kcal. The total energy used when movements of the respondent whole body while working are 300kcal/h. It can be concluded that the minimum metabolic rate of work after 8 hours is 336kcal/h. Based on the same guideline the Heat Stress Index of this workplace environment fall under the moderate category. Any system of controlling health and safety in hot environment should be embedded in management systems, including training of operators that can be used effectively worldwide.

Conclusion

The average temperature WBGT(in) at the steel plant was 29.1°C. Based on Threshold Limit Value (TLV) for WBGT(in) guideline (ACGIH, 2003), for moderate work this is in the category of mild stress workload and the recommended time is work duration to 50% and 50% rest every hour. Only in the EAF area has a low wind velocity based on guideline prescribed by ACGIH (2003). Workers in the EAF have the most thermal discomfort disorder compare to workers in the LF and CCM area. Continuous heat exposure to workers can affect the physiology of the body that will affect their health status. Measures such as engineering controls, administrative controls, training and monitoring of work and use of personal protective equipment should be emphasized in order to reduce the risk of heat stress.

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Research Article

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EFFECT OF PESTICIDES ON ACTIVITIES OF Alanine aminotransferase (ALAT) AND γ-glutamyltranspeptidase (GGT) IN BLOOD AMONG VEGETABLES FARMER IN MUAR, JOHOR, MALAYSIA

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Abstract

Most vegetable farmers are using agricultural chemicals on their farms. Many of these chemicals are used to control pests and are known as pesticides. Pesticides can be categorised according to their chemical basis. Most of the more toxic pesticides fall into chemical groups of organophosphates, carbamates and bipyridyls. The general objective is to study the level of liver enzymes as a result of being exposed to pesticides among the farmers in Muar, Johor. The specific objectives of the study are to identify relationship between pesticide exposure duration with the liver enzyme level, frequency of handling the pesticides and using PPE when applying the pesticides, comparing of the liver enzyme level between exposure group and comparative group and finally identifying the factor which can influence the liver enzyme lever at farmer who exposed to pesticides. The cross sectional study on the effect of pesticides to the liver enzymes among vegetable farmers at Muar, Johor was conducted by using the liver enzymes such as Alanine aminotransferase (ALAT) and γ-glutamyltranspeptidase (GGT) as indicators. 92 workers were selected as respondents, where 47 respondents are in the exposed group and the other 45 respondents in the comparative group. Respondents had been selected from farmers in Muar as the exposed group and respondents from Terengganu Health District Office as the comparative group. The selection of the respondents was made through purposive sampling from list provided. The liver enzyme levels were measured by taking blood from respondent. The Automated Analyser Hitachi 902 was used in the blood analysis. Two types of the liver enzymes (ALAT and GGT) were analyzed. Mean GGT for exposed group was 63.5 Units/L and ALAT was 61.9 Units/L, significantly higher compared to comparative group while the mean of GGT was 20.7 Units/L and ALAT was 23 Units/L. Non-parametric difference Mann-Whitney U test showed there was significant different between exposed and comparative group on GGT ($Z=-6.535$; p£0.001) and ALAT level ($Z=-5.315$; $p\leq 0.001$). Five occupational factors have been measured in this study was years of working, number of pesticide used per day, frequency of handling pesticide per day, pesticide spraying duration and personal protective equipment (PPE) scores. Result showed both GGT and ALAT enzymes level has significant correlations with pesticide spraying duration ($r=412$; $p=0.004$ & $r=0.445$; $p=0.002$) and personal protective equipment (PPE) scores ($r=-0.397$; $p=0.006$ & $r=-0.478$; $p=0.001$). Pesticides spraying duration was the occupational exposure factor which has most influence on GGT ($\beta=0.710$; $p<0.001$) and ALAT ($\beta=0.574$; $p<0.001$) enzymes level among exposed group after adjustments for all confounders in this study. This study found there are significant differences of liver enzyme (GGT & ALAT) levels between exposed group and comparative group due to pesticides exposure. This study also found there are significant correlations between liver enzyme (GGT & ALAT) levels with pesticide spraying durations (hours) and PPE score.

Key words: Pesticides, ALAT, GGT, PPE and vegetables farmers

Introduction

Pesticides are toxic chemicals that are widely used throughout the world. This broad category of compounds includes approximately 600 different active ingredients in use and a far greater number of commercial products. The main application of pesticides is in agriculture, although its use for public health programmes such as malaria or rodent control is also significant in some areas of the world (García 1998; Stopford 1999). Agricultural workers are exposed to pesticides primarily through mixing of chemicals, loading into dispensers, application, clean up, and disposal of empty chemical containers (El Sebae 1993; Geoffrey et al. 2003).

Pesticide damage primarily at the nervous system and neurobehavioral functions test method have been one of the method for detecting this damage in cross sectional workplace research (Bazylewicz-Walczak et al. 1999; Anger 1998; Stephens et al. 1995). Other than that, exposures to pesticide can be evaluated by measuring the level of liver enzymes such as Alanine aminotransferase (ALAT) and g-glutamyltranspeptidase (GGT) as a biological indicator (Di Lorenzo et al. 2003; Altuntas et al. 2002; Cheng et al. 1999; Giannini et al. 1999).

This study focuses on relationship between pesticide exposures with level of liver enzymes among the farmers in Muar, Johor. The specific objectives of the study are to identify relationship between pesticide exposure durations with the liver enzyme level, frequency of handling the pesticides and using PPE when applying the pesticides, compare the liver enzyme level between exposure group and comparative group and finally identify the factor which can influence the liver enzyme lever at farmer who exposed to pesticides. In agriculture base country like Malaysia, surprisingly there are relatively little liver enzyme researches on workers occupationally exposed to pesticides. In Malaysia, pesticides are typically applied to vegetable crops, palm oil plantations and tobacco farming. Safety measures are generally poorly applied and workers lack proper knowledge or training in safe handling of these chemicals.

Materials And Methods

Research ethic: An official permission letter was obtained from University Research Committee to ensure this study get cooperation from respondents. The purpose of the study was explained to the Vegetable Farmers Society in Muar district, Johor and Health District Office in Kemaman, Terengganu. All respondents in this study were volunteers who signed a statement of formal consent before testing. The consent form was developed according to the international ethical guidelines for biomedical research involving human subjects prepared by the Medical and Health Sciences Research Ethical Committee.

Sampling: This cross-sectional study using purposive sampling base on inclusion criterion. Forty seven (47) males were recruited from those who are working with pesticide in farms and meet the inclusion study criteria such as Malay or Indonesian, age in the range of 20 to 40 years old, no medical conditions such as diabetes mellitus, liver or kidney disease, immunology disorder, peripheral neuropathy, vitamin deficiency, anaemia and drug addiction, not alcohol drinker and not smoking and exposed to pesticide more than 5 years. Previous studies showed length of exposure more than 5 years to pesticides significantly showed the health impact (Altuntas et al. 2002; Bazylewicz-Walczak et al. 1999; Cheng et al. 1999). Comparative group are 45 male workers at Kemaman District Health Office and they also meet the inclusion study criteria except that they are not occupationally exposed to pesticides.

Instrumentations: Questionnaire was used to obtain the demographic, socio-economic and pesticide exposures among respondents. The questionnaire was administrated through face-to-face interview. Certified nurse took a 5 ml sample of venous blood under complete aseptic precautions from 47 exposed and 45 unexposed respondents. Blood samples were sent to certified university laboratory for analysis of Alanine aminotransferase (ALAT) and γ-glutamyltranspeptidase (GGT) using Hitachi 902 automated analyzer from Boehringer & Mannheim, Germany with standard method reagents (Verplanke et al. 2000). Blood samples were collected form all respondents after completion of the questionnaire and health examination.

Data analysis: All data were analysed using Statistical Package for Science Social (SPSS) version 11.5. Descriptive information generated from all variables. Non-normal distribution of variables for ALAT and GGT were transformed logarithmically, but the distributions are still not normal. Non-parametric Mann-Whitney U tests were used to compare the median of the ALAT and GGT between exposed and unexposed respondents. The Spearman's rho tests were used to define the correlation between occupational exposures with enzymes level. Repeated measurement analysis was performed with the multiple regression model using enter method to define the influence of occupational exposure on level enzymes of exposed workers after adjustment for confounders.

Results

Demographics: There are 92 volunteers respondent involved in this study. Forty-seven (47) of them are exposed to pesticide and 45 are comparative group. The mean age of the comparative respondents (32.7 years) was slightly older than that of exposed respondents (31.7 years), but the difference was not significant ($p=0.714$), (Table 1). The mean educational level of the exposed respondents was 9.1 years whereas the mean for the comparative group was 10.5 years. This difference was also not significant ($p=0.772$). The mean income of the comparative respondents (RM644.90) was slightly higher than that of exposed respondents (RM628.70), but the difference was not significant ($p=0.457$). The mean years of working of the exposed respondents were 11.4 years and the mean of that for the comparative group was 12.7 years. This difference was also not significant ($p=0.684$).

Liver enzymes level: Distribution of enzymes GGT and ALAT for exposed group is shown in Figure 1 and 2, meanwhile for comparative group it is shown in Figure 3 and 4. For exposed group, the mean of GGT was 63.5 Units/L and ALAT was 61.9 Units/L, significantly higher

Table 1 : Socio-economic background for all respondents

Variable	Mean ± SD		t value	p value
	Exposed (n=47)	Comparative (n=45)		
Age (years)	31.7 ± 8.1	32.7 ± 10.4	-0.944	0.714
Educational level (years)	9.1 ± 2.9	10.5 ± 2.2	-0.872	0.772
Income (RM)	628.7 ± 86.2	644.9 ± 94.4	-1.083	0.457
Years of working (years)	11.4 ± 6.1	12.7 ± 9.0	-0.788	0.684

N=92

Table 2 : Correlations between enzymes GGT and ALAT with occupational factors among exposed workers

Occupational factors	GGT level (Units/L)		ALAT level (Units/L)	
	r value	p value	r value	p value
Years of working (years)	0.144	0.333	-0.026	0.863
No. of pesticide used per day	-0.215	0.146	-0.258	0.080
Frequency of handling pesticide per day	0.142	0.341	0.106	0.476
Pesticide spraying duration (hours)	0.412	0.004**	0.445	0.002**
PPE scores	-0.397	0.006**	-0.478	0.001**

N=47
*** Significant at p ≤ 0.01, correlations using Spearman's rho Test*

compared to comparative group while the mean of GGT was 20.7 Units/L and ALAT was 23 Units/L. All of this data distribution was not normally distributed. Non-parametric difference Mann-Whitney U test showed there was significant difference between exposed and comparative group on GGT (p≤0.001) and ALAT level (p≤0.001), (Table 2).

Occupational factors and liver enzymes: Five occupational factors have been measured in this study which are years of working, number of pesticide used per day, frequency of handling pesticide per day, pesticide spraying durations and personal protective equipment (PPE) scores. Result showed both GGT and ALAT enzyme levels have significant correlation with pesticide spraying durations (p=0.004; p=0.002) and personal protective equipment (PPE) scores (p=0.006; p=0.001), (Table 2). Pesticides spraying duration was the occupational exposure factor which has most influence on GGT (p<0.001), (Table 3) and ALAT (p<0.001), (Table 4) enzyme levels among exposed group after adjustments for all confounders in this study.

Discussion

Table 1 showed this exposed and comparative group also have been matched successfully with their age (p=0.714), educational level (years) (p=0.772), income (RM) (p=0.457) and years of working (years) (p=0.684).

Results showed that was a significant difference between exposed and comparative groups for GGT and ALAT enzyme levels. Mean value for GGT enzyme of exposed group was 63.5 ± 46.5 U/L which is 3 times higher compared to the comparative group which was 20.7 ± 23.1 U/L. Same pattern of results for enzyme

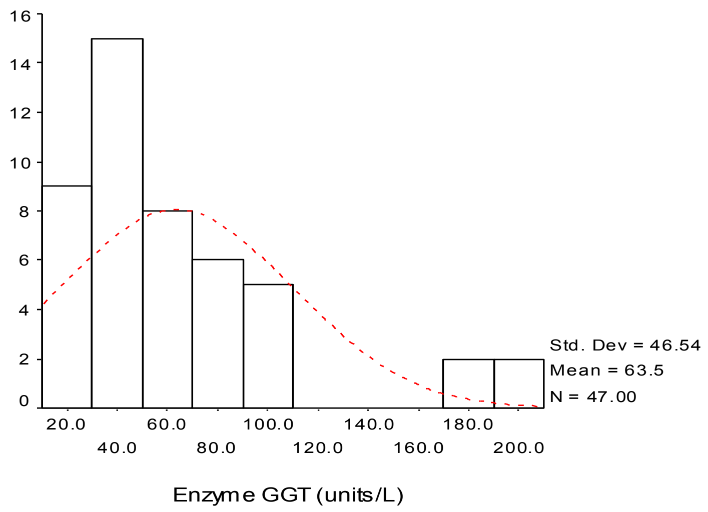

Figure 1 : Distributions of enzyme GGT among exposed respondents

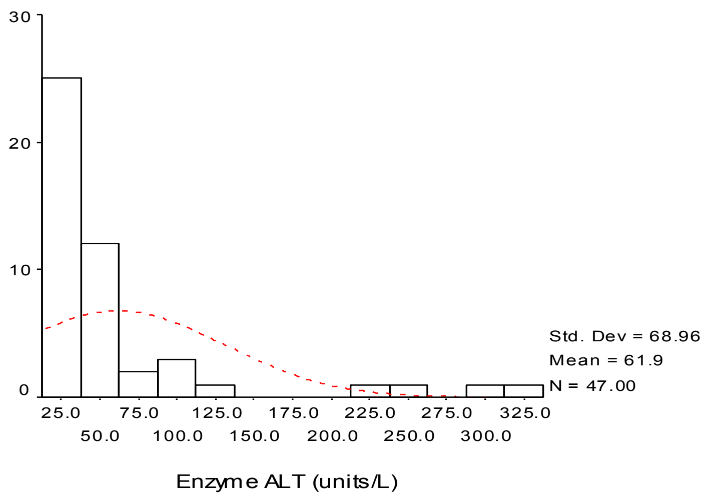

Figure 2 : Distributions of enzyme ALAT among exposed respondents

ALAT, where the mean value for exposed group was 61.9 ± 68.9 U/L meanwhile for comparative group was 22.9 ± 10.8 U/L.

Increments of liver enzymes are significantly higher among individuals who were exposed to pesticides and that was the fact supported by many previous studies (Arndt et al. 1998; Mage et al. 2000; Bazylewicz-Walczak 1999). Study by Azizi 2000, purposely to investigate the effects of insecticides on liver enzymes among sprayers working at Health Department of Kuala Lumpur Municipal Council also found that AST, ALAT and GGT enzymes were significantly higher in exposed group compared to comparative group. Upfal, 1992 in his study also found that liver enzyme levels among technical and services electronic workers are higher and not normal and they caused by exposure to organic solvents such as xylene, acetone, benzene and others.

This study also found that pesticide spraying durations and total PPE scores were the only factors significantly influencing the level of GGT and ALAT enzyme of exposed group. Other factors such as years of working, number of pesticides used per day and frequency of handling pesticides per day was not significantly correlated with level of liver enzymes. Study by Arndt 1998, found that were no significant correlations between exposure duration of organic solvents on increasing of liver enzymes among construction workers, but the level of liver enzymes are significantly higher compared to normal populations. Bazylewicz-Walczak, 1999 in his study found that years of education, pesticides spraying durations and total PPE score were the major factors contributed to liver enzymes increment among agriculture workers. Another study by Tomei et al. 1998, found there were significant correlation between years of working with liver enzymes level among environmental disinfestation workers.

Study by Sunding and Zivin 2000, found that pesticide poisoning was influenced by the frequency of handling pesticide per day, number of pesticide used per day and pesticide spraying durations. This study also found the levels of enzyme GGT and ALAT of exposed group was significantly influenced by pesticide spraying durations ($r=0.412$; $p=0.004$), ($r=0.445$; $p=0.002$) and total PPE scores ($r=-0.397$; $p=0.006$), ($r=-0.478$; $p=0.001$).

Others study by Tomei et al. 1998 and Giannini et al. 1999 were designed to study the liver damage cause by toxic waste and pesticides in occupational exposure. These study found the amount of pesticide dose, duration of spraying time and the PPE application have a significant correlations with liver diseases.

This study also has the confounding factors such as demographic and socio-economic factors. In multiple regression statistical analysis after adjustment of the confounding factors, result shows that frequency of handling pesticide per day ($\beta=0.341$; $p=0.020$) and pesticide spraying duration (hours) ($b=0.710$; $p<0.001$) influence the enzyme GGT level among exposed workers. Meanwhile this study also found that years of working (years) ($\beta=-1.121$; $p=0.034$) and pesticide spraying duration (hours) ($\beta=0.574$; $p<0.001$) influence the enzyme ALAT level among exposed workers, after adjustment of the confounding factors. Study by Sunding and Zivin 2000, also found the supportive results which is after adjustment of their study confounding factors they still get the significant correlation between GGT level with frequency of handling pesticide per day, number of pesticide used per day and pesticide spraying durations.

Conclusion

In conclusion, this study found there are significant differences of liver enzyme (GGT & ALAT) levels between exposed group and comparative group due to pesticides exposure. Other than that this study also

Table 3 : The influence of occupational exposure on GGT enzyme level of exposed workers after adjustments for confounders

Independent Variable	GGT enzyme level (Units/L)		
	Regression coefficient (β)	t value	p value
Constant (α)	-147.402	-1.372	0.178
Age (years)	0.353	0.892	0.378
Educational level (years)	-0.198	-1.153	0.256
Household income (RM)	0.411	1.006	0.321
Years of working (years)	-0.850	-1.937	0.060
No. of pesticide used per day	0.085	0.622	0.538
Frequency of handling pesticide per day	0.341	2.427	0.020*
Pesticide spraying durations (hours)	0.710	6.676	< 0.001**
PPE scores	-0.159	-1.348	0.186

N=47
* *Significant at* $p \leq 0.05$
** *Significant at* $p \leq 0.01$

$r = 0.798$ $R^2 = 0.561$ *(enter method)*
$F = 8.345$ $p \leq 0.001$

Table 4 : The influence of occupational exposure on ALAT enzyme level of exposed workers after adjustments for confounders

Independent Variable	ALAT enzyme level (Units/L)		
	Regression coefficient (β)	t value	p value
Constant (α)	-190.279	-1.027	0.311
Age (years)	0.653	1.418	0.164
Educational level (years)	-0.156	-0.778	0.441
Household income (RM)	0.274	0.576	0.568
Years of working (years)	-1.121	-2.196	0.034*
No. of pesticide used per day	-0.020	-0.127	0.899
Frequency of handling pesticide per day	0.218	1.336	0.189
Pesticide spraying durations (hours)	0.574	4.635	< 0.001**
PPE scores	-0.111	-0.809	0.424

N=47
* *Significant at $p \leq 0.05$*
** *Significant at $p \leq 0.01$*

$r = 0.713$ *$R^2 = 0.405$ (enter method)*
$F = 4.919$ *$p \leq 0.001$*

found there are significant correlations between liver enzyme (GGT & ALAT) level with pesticide spraying durations (hours) and PPE score. After adjustment of the confounding factors, result shows that frequency of handling pesticide per day and pesticide spraying duration (hours) influence the enzyme GGT level among exposed workers, meanwhile years of working and pesticide spraying duration (hours) influence the enzyme ALAT level among exposed workers.

Aknowledgement

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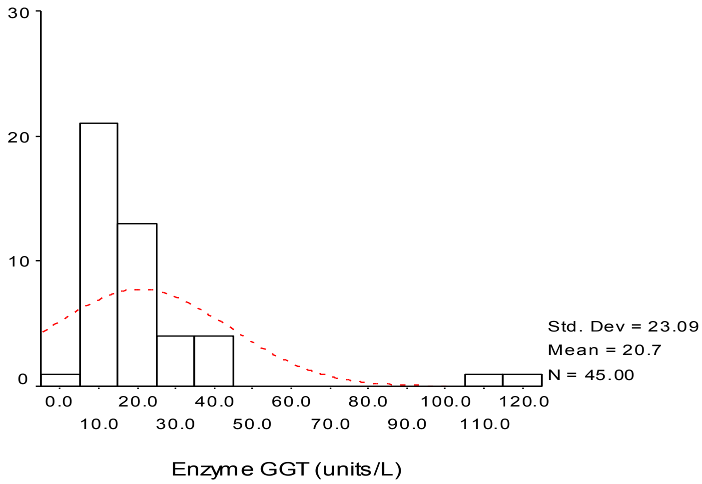

Figure 3 : Distributions of enzyme GGT among comparative respondents

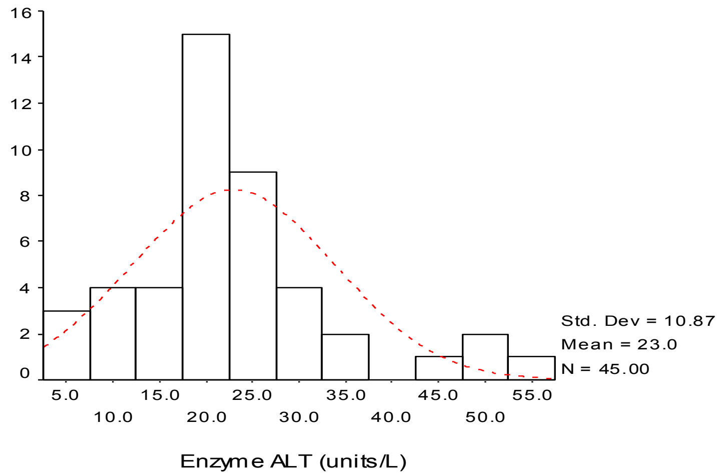

Figure 4 : Distributions of enzyme ALAT among comparative respondents

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DNA Changes in Lymphocytes among Malaysian Traffic Police Officers Exposed to Air Pollutants

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Abstract

Traffic policemen are exposed to air pollutants in their daily work. Air pollutants which may come from vehicle exhaust, contains genotoxic and carcinogenic substances, such as polycyclic aromatic hydrocarbons (PAHs) and benzene. To compare the DNA damage in lymphocytes of traffic policemen exposed to air pollution with non-exposed indoor workers and if any other individual, occupational and environmental factors were associated with DNA damage. A cross-sectional study was undertaken to determine DNA damage in peripheral blood lymphocytes in three urban areas in Klang Valley in Malaysia among traffic policemen and control indoor workers. Single Cell Gel Electrophoresis (SCGE) or Comet Assay was carried out on blood samples to determine the extent of DNA damage. A total of 66 participants, comprising of 34 traffic police officers and 32 indoor office workers were recruited. There was a significant difference between the percentage of mean Percent Tail DNA (damaged DNA) of the two groups, that is 6.4% among the traffic police officers and 5.7% among indoor workers. Number of cigarette-years showed a significant, moderate association with increased DNA damage in lymphocytes. There was increased DNA damage in lymphocytes of traffic police officers compared to indoor workers. Other factors associated with increased DNA damage was the number of cigarette-years and geographical location. More studies are required to look at the long term effects or constant exposure to environmental vehicle exhaust. Steps should be taken to reduce exposure to air pollutants among traffic policemen.

Key words: DNA damage, Comet assay, single-cell gel electrophoresis, policemen, air pollution.

Introduction

Outdoor workers are exposed to outdoor air pollution which may occur naturally or are man-made. With industrialization, many factories and vehicles emit smoke which affect air quality. Exposure to constituents of air pollution can damage bio-molecules in humans and animals and cause diseases such as cancer (Kampa,2008; Moller,2008; Risom, 2005). Man-made air pollution consists of polycyclic aromatic hydrocarbons (PAH) and volatile organic compounds (VOC) which derive from combustion processes associated with industries and traffic vehicles (Moller;2008). Exposure to outdoor air pollution and its particulate matter has been classified as carcinogenic to humans by the International Agency for Research in Cancer (IARC,2014). Increased DNA damage was seen in lymphocytes of workers exposed to traffic exhaust and persons living in areas with air pollution. Oxidative DNA damage in circulating lymphocytes has been associated with exposure to ozone, benzene, carcinogenic polycyclic aromatic hydrocarbon (c-PAH) concentrations in air (Fanou,2006; Palli,2009; Singh 2007[a]; Sul,2005).

Studies have been conducted to look at the DNA damage among workers exposed to air pollutants, which include outdoor workers, policemen in Prague and Rome, coke oven workers, and rickshaw pullers (Carere, 2002; Novotna, 2007;Tovalin,2006;Wang, 2007). Greater DNA damage was seen among outdoor workers in Mexico City and related to higher levels of PM 2.5, ozone and some VOCs (Carere, 2002). A study among Prague policemen outdoors showed higher DNA damage in those who worked outdoors compared to indoors (Wang, 2007). DNA damage in lymphocytes may be affected by other factors, such as air pollution exposure levels, tobacco smoking and genotype variability (Carere, 2002; Novotna,2007; Singh,2007[b]). Physical activity and dietary intake of micronutrients such as certain vitamins may also play a role in DNA damage in blood lymphocytes (Fenech,2011, Lee, 2009;Pandey,2006;Singh, 2007[b]).

Many environmental and occupational studies use the Comet Assay (Single Cell Gell Electrophoresis) to evaluate DNA damage (Faust, 2004; Moller, 2006; Velverde,2009). The alkaline comet assay detects DNA double strand breaks, single-strand breaks, alkali labile sites and DNA cross-linking. Isolated peripheral blood lymphocytes undergo electrophoresis on agar and cells are seen as 'comets'. Damaged DNA will be seen as 'comet tails' which are analysed. DNA damage can be estimated with the use of a computerized automated image analysis system (Velverde,2009). Percent Tail DNA (%Tail DNA) appears to be the best measurement to conceptualize DNA damage (Kumaravel,2006;Moller,2006).

The aim of this study was to compare the DNA damage in lymphocytes of traffic policemen exposed to air pollution with non-exposed indoor workers and if any other individual, occupational and environmental factors were associated with DNA damage.

Materials And Methods

Study subjects: A cross-sectional study was undertaken in Klang Valley, Malaysia, under non-haze conditions, among volunteer traffic police officers in the urban areas of Kuala Lumpur, Ampang and Shah Alam in Malaysia. All areas were busy urban areas with many offices and heavy traffic circulation. As for the non-exposed group, they were indoor office workers from the same areas who were not occupationally exposed to strong chemicals, petroleum fumes, air pollution or physically strenuous activities. Only male participants were chosen as the vast majority of traffic policemen are males in Malaysia and controls were matched by age and location to the exposed study samples.

Self-administered questionnaires: Participants filled out questionnaires, for demographic details and factors that may contribute to DNA damage such as smoking habits, prior physical activity, hobbies, recreational activity, mode of transportation and other exposures to air pollution such as proximity of living quarters to high traffic areas, factories and petrol kiosks.

Blood sampling: Blood was collected by finger prick at mid-morning for both groups of workers, which coincide with after the early morning traffic duty for traffic policemen. Samples were taken in dim lighting conditions (to reduce DNA damage by UV light) and transported in heparinised plain tubes, shielded from light. The samples were transported at 4°C to the laboratory where they were processed immediately, also in dim lighting conditions.

DNA damage analysis: For DNA damage analysis, the alkaline version of the Single Cell Gell Electrophoresis (SCGE) or Comet Assay was carried out on blood samples to determine the extent of DNA damage to lymphocytes. Ten-microlitres of blood was mixed with 80 µl of low melting agar (LMA). This mixture was placed on a layer of solidified normal melting agar on a slide and covered with a coverslip. The slide was placed in a cold lysis buffer solution: 2.5M NaCl, 10mM Dinatrium EDTA, 10mM Tris, 1% Triton X-100 and 10% DMSO. After 1 hour, slides were removed and drained, and placed in electrophoresis apparatus filled with electrophoresis buffer (freshly made and cold): 300mM NaOH, 1 mM EDTA and left for 20 minutes for the DNA to unwind. Electrophoresis was later carried out (voltage of 25 V, current of 300 mA) for 20 minutes. The slides were then drained and washed with a neutralisation buffer (3 times, with 5 minutes in between). The drained slides were then stained with 45µl of ethidium bromide, placed in light-proof boxes and kept moist with PBS. Two slides were prepared for each respondent. An Olympus fluorescence microscope connected with a CCD camera was used to capture pictures of 50 lymphocytes on each slide, at random, for analysis of DNA damage. A total of 100 pictures of lymphocytes were analysed for damage using the Komet 6.0 Software (Kinetic Imaging Ltd.) on a computer. Average percent tail DNA readings were taken for each respondent.

Statistical analyses: For data analysis, the statistical software SPSS Version 16.0 was used. Data was examined for skewness and as there was normal distribution, parametric tests were carried out. Continuous variables were analysed by Independent-Samples T-test and one-way ANOVA (analysis of variance). Pearson's correlation was used to determine correlations between risk factors and DNA damage (% tail DNA).

Ethical approval: The study was conducted with the approval of the Medical Research Ethics Committee of the Ministry of Health, Malaysia. Respondents were given information leaflets and briefed on the details of the study. Informed consent was obtained from each respondent.

Results

There were 66 respondents in the study, which comprised of 34 male traffic police officers and 32 male indoor office workers which consisted of hospital attendants, clerks, researchers, executives, trainers and operators. There was no significant difference between age and smoking status between the traffic policemen and the indoor workers group. However, the policemen significantly smoked more cigarettes per day, compared to the indoor worker group. They were all significantly more exposed to environmental tobacco smoke (passive smoking) either at home or at their workplaces compared to the indoor workers, where 84.4% were exposed (see Table 1).

All the traffic policemen used motorcycles for mode of transportation while the indoor workers used mostly motorcycles (56.3%), followed by cars (31.3%), bus (9.4%) and the minority walked to work (3.1%). For the exposed group, the majority (73.5%, n=25) worked 5 years or less in traffic duty, with a mean of 6 working days a week (mean=6.2, s.d.=1.0) with 7

Table 1. Demographic details of respondents and exposure to tobacco

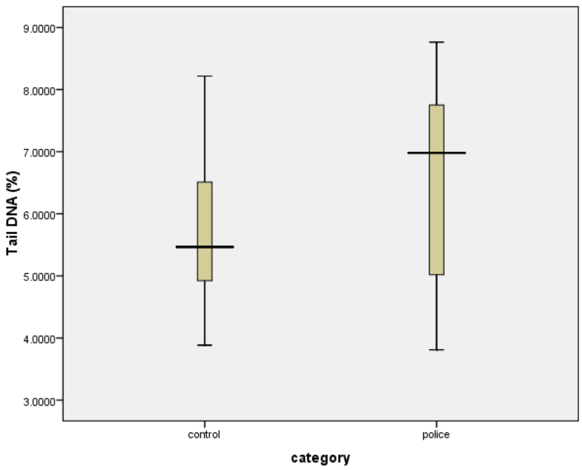
	Traffic Policemen (n=34)	Indoor workers (n= 32)	p-value
Age (mean, s.d.)	35.2 (s.d.=9.21)	36.6 (s.d.=10.99)	0.59
Smoking status (n, %)	18 (52.9%)	15 (46.9%)	0.62
Cigarettes per day (mean, s.d.)	15.83 (s.d.=5.22)	8.28 (s.d.=6.11)	***<0.001****
Environmental tobacco smoke (n,%)	34 (100%)	27 (84.4%)	***0.023****
Workplace:			
Kuala Lumpur	10	12	0.674
Ampang	10	10	
Shah Alam	14	10	
Mean years in service (mean, s.d.)	13.70 (s.d.=8.98)	10.51 (s.d.=11.26)	0.207

**denotes significance of p-value <0.05*

hours of daily exposure to traffic (mean=6.8, s.d.=2.4). The majority of traffic policemen (79%, n=27) did not wear any face masks while on duty, while 12 % (n=4) used them sometimes and 9 % (n=3) rarely used them. It was commented by some respondents that face masks hindered their use of their police whistles while on duty.

DNA damage: Overall, there was significantly more DNA damage among the traffic policemen. The mean % tail DNA among the traffic policemen was 6.42% (s.d.=1.60), while in the non-exposed indoor workers, it was 5.74% (s.d.=1.04) (p=0.042). (Figure 1)

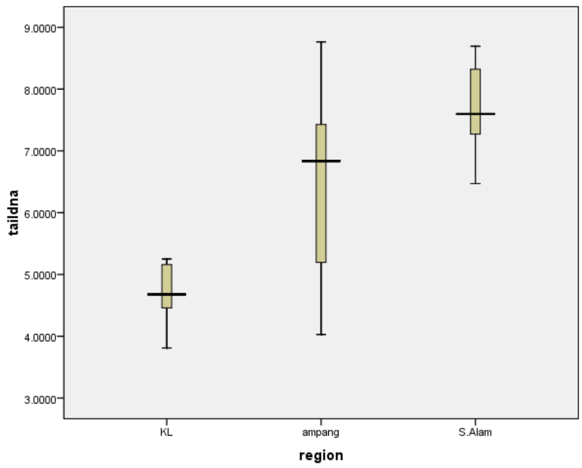
Figure 1. Distribution of %Tail DNA among respondents



By geographical location, overall, respondents from Kuala Lumpur had the lowest DNA damage, % tail DNA was 5.62% in Kuala Lumpur, 5.90% in Ampang and highest at Shah Alam, at 6.69%. There was a significant difference between the % tail DNA percentage between Shah Alam and Kuala Lumpur (p=0.023). This was similarly reflected among the police traffic officers, where there was a significant difference between % tail DNA of all three areas, with Shah Alam having the highest DNA damage (7.69%), followed by Ampang (6.39%) and Kuala Lumpur which had the lowest DNA damage (4.69%) (p< 0.001) as shown in Figure 2 and Table 2.

There was no significant difference of DNA damage (% tail DNA) between smokers and non-smokers in general. However, a significantly moderate increase in DNA damage was associated with the number of cigarette-years of respondents (multiplication of sticks of cigarettes and years of smoking) (r=0.425, p=0.014). No significant correlation was found between age and DNA damage. See Tables 2 and 3.

Figure 2. Distribution of %Tail DNA among traffic police officers at different workplaces.



Among the police officers, there was no significant increase in the percentage of Tail DNA with years in traffic duty or weekly hours of exposure. Due to the small sample size and that all the traffic policemen used motorcycles as their main mode of transport, analysis of DNA damage according to most frequent mode of transport was not feasible. Information on other exposures to air pollution such as part-time work or hobbies involving petrol or strong chemicals, or living near petrol kiosks, heavy traffic areas, rubbish dumping grounds or printing factories were also obtained. Respondents were also asked if they had engaged in rigorous exercise (which could also induce DNA damage) on the morning before their blood was taken. However, very few respondents answered “yes” to any of these factors, so they could not be analysed.

Table 2. DNA damage among respondents

		DNA damage (%Tail DNA)	p-value
Respondent Group	**Traffic Policemen**	6.42	
	Controls	5.74	***0.042****
Smoking Status	**Smokers**	6.18	
	Non-smokers	6.00	0.589
Geographical location	**Kuala Lumpur**	5.62	
	Ampang	5.90	
	Shah Alam	6.69	***0.023****

(*)denotes significance of p-value which is less than 0.05

Table 3. Correlation between DNA damage and individual and working factors

Factors	Correlation, r	p-value
Age	0.085	0.499
Cigarette-years	***0.425***	***0.014****
(‘cigarettes a day’ x ‘number of years of smoking’)		
Years in traffic duty (for policemen)	0.216	0.221

(*)denotes significance of p-value which is less than 0.05

Discussion

Many factors can influence DNA damage. Such factors include age, smoking, gender, diet, exercise and exposure to air pollution (Fenech,2011; Moller,2006). A pooled analysis also found a negative correlation with latitude and DNA damage (Moller,2006). Genotype variability also appears to play a role in a person’s susceptibility to DNA damage and vitamin C tended to protect DNA integrity (Novotna,2007).

Our preliminary study reflects similar results of increased DNA damage in lymphocytes of outdoor workers exposed to air pollutants such as in other studies (Novotna,2007; Palli,2009;Tovalin,2006). A study among police officers in Prague found that among non-smoking police officers, those who worked outdoors had more DNA damage in lymphocytes compared to those who worked indoors, and this damage showed inter-seasonal variability, with more DNA damage seen in the colder climate, when there was a higher level of c-PAHs (carcinogenic polycyclic aromatic hydrocarbons) and particulate matter (PM 2.5) in the air (Giovanelli,2006; Novotna,2007). Seasonal variability may not be applicable to the tropical climate of a country like Malaysia. Studies among persons exposed to increased traffic air pollution, such as children in Thailand (Buthbumrung,2008), residents in urban areas in Benin (Fanou,2006) and Shenyang city in China (Ishikawa,2006), also showed increased DNA damage in lymphocytes. Another study carried out at Mexico City and Puebla showed that DNA damage in lymphocytes increased with more exposure to particulate matter, PM 2.5, ozone, and 1-ethyl, 2-methyl benzene exposure (Tovalin,2006). A study among residents in Florence, Italy also showed a positive association between DNA damage and exposure to air pollution, and this was also seen among those who were occupationally exposed (Palli,2009). A recent cohort study following up Taiwanese traffic conductors between the years 2009 to 2011 provide further evidence to link between exposure to fine particulates in air pollution to DNA damage (Huang,2012).

Another occupational health study looked at rickshaw pullers in India, where heavy physical activity for 7 to 9 hours of pulling rickshaws in polluted outdoor air caused increased DNA damage compared to other outdoor workers who did not engage in heavy physical activity outdoors (Pandey,2006). Smoking and increasing age have been shown to be associated with peripheral lymphocytic DNA damage in some studies (Carere,2002; Fracasso,2006; Moller,2006; Zhu,2001). Our study showed a moderate significant correlation between cigarette-years (number of cigarettes per day multiplied by number of years of smoking) and DNA damage seen in lymphocytes ($r=0.43$, $p=0.014$). However, no significant relationship was found between age and DNA damage in our sample.

Geographical variations may occur due to the topography of the area where respondents were tested. In general, significantly higher DNA damage was found in persons working in Shah Alam in our study. The reason for this is uncertain. Further studies are required to look at air quality indices which may vary between the three urban sites. In past years, Shah Alam suffered poor air quality (more so than the neighbouring cities) when Malaysia was affected by trans-boundary haze. In this study, environmental factors, such as the topography or existence of factories, may have a role in the level of air pollutants exposure among traffic policemen and DNA damage that occurs in lymphocytes.

Study limitations include the cross-sectional study design which shows only the DNA damage of participants at one point of time. The results should be interpreted with care as there was a small sample size and that it was conducted on volunteers. Another limitation is that workers commute daily and may live in one area and work in another city. Future studies could focus on a longitudinal study and include more respondents to allow analysis of occupational, environmental or other individual exposure factors. Personal air samplers for workers to wear would capture real-time air exposures to the different types and levels of air pollutants at the breathing zone. A concurrent study on air quality in the geographical locations will give more insight on environmental factors which affect exposure to air pollutants among exposed workers. Also, the availability of an automated DNA damage analyser would increase efficiency of sample analysis, as analysing DNA damage individually for each sample of blood lymphocyte is time-consuming.

Policemen should be educated to be aware of the hazards of exhaust fumes and encouraged to wear respirators or masks for protection. Masks designed for police should take into account their need to blow whistles and communicate to drivers to direct traffic effectively. Reduction of exposure to such fumes can be achieved by reducing traffic duty hours and rotation of schedules between police officers. More steps could be taken to encourage the public to take public transport, car pool or use electric cars to reduce traffic emissions. Traffic policemen should also be followed up with health assessments (Gupta, 2011). It would also be recommendable that all cancer registries include the occupation of patients. This would facilitate detection of malignancies among different categories of workers and prompt any preventive measures.

Conclusion

There was increased DNA damage in lymphocytes of traffic police officers compared to indoor workers. Other factors associated with increased DNA damage was the number of cigarette-years and geographical location of Shah Alam, compared to Kuala Lumpur and Ampang. More studies are required to look at the long term effects of constant exposure to environmental vehicle exhaust. Efforts should be taken to reduce traffic policemen exposure to exhaust fumes.

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