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Contents

From the Chief Executive Editor

Workplace safety is a priority. Much needs to be done to encourage employees, employers and industries to position occupational safety and health at the top of their agenda. The imperative focus is our commitment to take action; and make the necessary changes to ensure that safety is viewed as the "Top of Mind Awareness" for everyone.

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

I would like to highlight the article titled "A Survey on Return to Workplace Measures During Recovery Phase of COVID-19 Pandemic Among Malaysian Corporate Health Adviser's Forum (MCHAF) Members". A survey was conducted among MCHAF members to ascertain measures taken by their organizations during the recovery phase of COVID-19 Pandemic. Based on the survey, all organizations have fully complied with the mandatory requirements from the authorities for the workplace, such as practising physical distancing, conducting temperature screening, compelling health declaration, and the use of mask and enhancing cleaning protocols. Most of the organizations also instituted additional measures which were all aligned with the principle of facilitating reduction of COVID-19 transmission in the workplace.

It is our hope that the contents of the journal will be read and reviewed by a wider audience, allowing for a more vast academic base, while there should also be an increased cumulative experience to draw on for debate and comment within the journal.

We aspire that the journal will be advantageous to all readers, as our objective is to serve the interest of everyone across all industries. Prime focus will be on issues that are of direct importance to our everyday practices.

I would like to take this opportunity to personally welcome all our readers and contributors to JOSH (Vol 17, No 1). I am eager to receive more contributions from the Malaysian OSH community and also from elsewhere for our upcoming issues.

Haji Ayop Salleh
Chief Executive Editor

Original Article

Control Banding for Chemical Health Risk Assessment (CHRA) Conducted at Quarry Industries.

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ABSTRACT: *Quarrying activities have tendency to generate a number of safety, health and environment issues. An assessment of the adverse health effects should be done properly in managing risk at the industry. However, current CHRA assessment varies from one organization to other organizations, depending on* assessor's *own perspective. Therefore, this study evaluates the findings of CHRA report from various quarry organizations, aiming to compare an existing method with control banding method in conducting CHRA at quarry industries. A control banding method is used to analyze the chemicals involved in CHRA reports and further compared the control measure findings with the result of CHRA method done by assessors. It was found that there are inconsistency of hazard rating and control measure assessed by the assessors. Based on the findings, the control banding is proposed to be used by the CHRA assessors at quarry industries. This control banding approach is simpler and comprehensive in controlling the chemical hazard as compared to the CHRA method. The level of adequacy of control in the studied quarries was observed at moderate level which was around 35.1%. The employers and employees shall have the responsibility to prevent the adverse effects of chemical exposure by practicing a healthy and safe work culture at workplace.*

Keywords: *Chemical Health Risk Assessment, Control Banding, Control Measures, Health Risk Assessment; Quarry*

1.0 INTRODUCTION

The use of chemicals is widespread throughout the world to meet various aspects of human life. Chemicals can be found in variety of forms namely liquids, gases and solids. In Malaysia, the uses of chemicals in any industries need to comply with act and regulations under the Occupational Safety and Health Act 1994 and Factories and Machinery Act 1967. According to Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000 (USECHH Regulations), chemicals are defined as elements, compounds or mixture whether natural or synthetic (DOSH, 2000).

The operation of the quarry often uses chemicals that are hazardous to health in their activities. Each chemical could give hazardous effect to the human health depending on the type of chemicals. The classification of hazardous effects are varies such as corrosive, toxic, flammable, explosive, radioactive or reactive. According to the International Labour Organization(ILO, 2013), one worker dies from a work related accident or disease in every 15 seconds, and 151 workers have work-related accident in every 15 seconds Quarrying industry has often been termed as particularly 'unhealthy industry' due to the high number of accidents, injuries, illnesses and fatalities (Smallwood J.J and Haupt T.C., 2000). Apart from that, quarrying also has been reported as one of the most dangerous industries to work due to its contributions toward the number of accidents (HSE, 2018b; Okafor,

2006). HSE UK website has reported that since 2000, around 3500 workers have suffered an injury and 31 of those being fatal.

In 2017, around 242 quarries registered their activities with the Department of Occupational Safety and Health Malaysia (DOSH, 2017). All of them are actively operated up to now. Under the USECHH Regulations 2000, it is requirement for quarry operators to perform the chemical health risk assessments (CHRA). This assessment should cover the chemicals that are produced, processed, used, stored, transported, disposed and treated at the quarry site.

A CHRA assessor is responsible to carry out the assessment at quarry industry. However, current CHRA assessment are varies from one organization to other organizations, depending on assessor's own perspective. Nowadays, there are several methods available to conduct the chemical health risk assessment. A suitability and effectiveness of each method need to be evaluated in order to improve a chemical risk management. Although CHRA has been carried out, we are still witnessed an increasing cases related to safety and health issues in these industries. This reflects that the current practice of occupational safety and health management required improvement to make it more relevant to the quarry industry. Therefore, this study evaluates the findings of CHRA report from various quarries organization, aiming to compare an existing method with control banding method in conducting chemical health risk assessment at quarry industries.

2.0 METHOD

This study used both primary and secondary resources. The primary data was obtained through site observation and in-depth interview with quarry personnel and assessor that conduct the CHRA in quarry. The secondary data was obtained from the chemical health risk assessment report conducted at thirteen quarries located in east Peninsular Malaysia. An explanatory sequential mixed method with both evaluation approaches, quantitative and qualitative, were used in this study. Qualitative data is necessary to explain the details of the data obtained from quantitative findings (Cresswell, 2013). The CHRA reports contain information that valuable in this study. From the report, the information that were reviewed include the worker at risk, work unit involved in the process, degree of hazard in quarry, exposure evaluation, control measure and the methodology of the assessment. All of this information were recorded and grouped into the same category for each report.

Site Observation was used in this study to evaluate the real situation during normal quarry operation. The unstructured observation was performed to observe and record behaviour without the use of a pre-determined guide. All senses were used to examine people and environment in natural setting or natural occurring situations. The purpose of this observation was to get information about people behaviour toward chemical handling and their nature and culture of work in quarry industry. Two quarries were observed in this study.

CHRA Assessor who conducted the CHRA in quarry industry was chosen to have a one to one structured interview session. Interviewees were selected based on their experience in conducting CHRA at various quarries operation and facilities in east peninsular Malaysia. The questions were open-ended, and aimed to obtain further details and explanation about the CHRA results. The collected answers were analyzed to identify how the CHRA was conducted and how the control measures were proposed to the industry.

Then, the gathered information was assessed by using control banding approach. Guidelines from NIOSH control banding method and COSHH Essentials were used. The hazard was band according to three tiers method which includes tier 1, tier 2 and tier 3. In tier 1, the chemical are band by using GHS information, tier 2 is banding the chemical which is beyond the GHS information and tier 3 is using expert judgments to evaluate data experiment (HSE, 2018a; NIOSH, 2017).

3.0 RESULTS AND DISCUSSION

The number of chemicals that have been assessed by the assessors at 13 quarries are shown in Fig. 1. There were in a range of 9 to 27. There were four quarries exposed to 9 chemicals (quarry operator no. 3, 5, 9 and 13). Two quarries were exposed to 10 chemicals (quarry no. 2 and 3), 12 chemicals (quarry no.1 and 12) and 15 chemicals (quarry no. 8 and 10). The rest are quarry operator 6 that exposed to 14 chemicals, quarry operator 7 exposed to 20 chemicals and the highest number of chemical that had been exposed was 27 by quarry no.11. Based on the data in Fig. 1, it was found that each quarry had been assessed with different number of chemicals used due to their different inactivities. Some quarries have either a premix plant or concrete mix plant or both types. A number of chemical assessed by assessors is based on the registered chemicals by the quarry operator as well as at onsite observation.

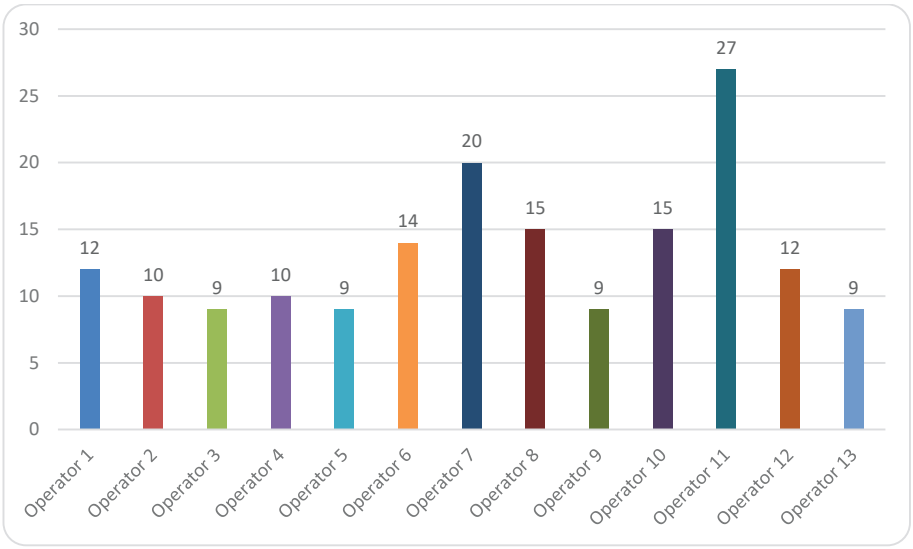

Figure 1 Number of Chemical Assessed at Each Quarry Operator

Table 1 shows a summary of hazard rating obtained from CHRA reports conducted by 8 assessors. It was found that the assessors gave different hazard rating (HR) in some of the chemicals that were exposed to the workers. . These include granite, acetylene, gear oil, engine oil, diesel, grease, compress oxygen, welding fumes, hydraulic oil and emulsion explosive. The rest of the chemicals listed in the Table 1 were consistently rated. Based on the structured interview with the assessors, they mentioned that the different rating for HR may be due to:

- Different interpretation or understanding of classification methods from the CHRA manual and Industrial Code of Practice (ICOP) 2014 on chemicals classification.
- Difficulty to choose most appropriate hazard rating due to conflicting data in Safety Data Sheet (SDS) e.g. toxicity data may not be similar with hazard identification mentioned in the same SDS. Most of the quarry do not have SDS for the product especially granite and quarry dust. Assessors have to search and download SDS for granite and quarry dust from internet. The hazard rating will be different from country to country as well as quarry operator depending on the mineral of soil.
- SDS data may not be reliably used with confidence and hence have to rely on classification from published literatures or ICOP 2014 chemicals classification.

Table 1 Hazard Rating Analysis Based on Chemical Assessed by Assessor

Chemical	Hazard Rating				
	1	2	3	4	5
Granite			✓	✓	
Limestone			✓		
Acetylene		✓	✓		
Gear oil	✓	✓	✓		
Engine oil	✓	✓			
Diesel		✓	✓		
Grease	✓	✓	✓	✓	
Compress oxygen		✓	✓		
Welding fume		✓	✓	✓	
Welding electrode		✓			
Hydraulic oil	✓	✓		✓	
Kerosene		✓			
Waste oil				✓	
Cement			✓		
Engine oil treatment	✓				
TMB power coolant			✓		
Chemicide 75				✓	
Glyphosate isopropylamine			✓		
Metsulfuron methyl			✓		
Bitumen			✓		
Asphalt			✓	✓	
Emulsion explosive		✓	✓		
Zinc dust		✓			
Bakelite powder	✓				
Ammonium nitrate			✓		
Repumpable matrix			✓		
calcium hidroxide			✓		
Sulfuric acid				✓	
Sodium cyanide				✓	
Cyanide				✓	
Hydrochloric acid				✓	
Nitric acid				✓	
Methylene chloride			✓		
Bituminoues solution			✓		
Ethyl alchohol				✓	
Thiourea				✓	

Table 2 illustrates the analysis of adequacy of control measures in each studied quarries obtained from CHRA reports. Based on the risk decision and the assessment of existing control measures, the risk that workers are being exposed concluded as C1, C2, C3, C4 and C5 where C1 is a risk are not significant while C2 is a risk that significant but in adequate controlled and C3 is a risk that significant but not in adequate controlled. From the analysis there is no assessment conclusion felled under the category C4 which is insufficient information about chemical and C5 was about uncertain information of chemical exposure.

Based on the result shown in Table.2, most of the total chemicals assessed in 13 quarry operators were adequate controlled with percentage of 35.1% followed with inadequate controlled with percentage of 32.7%. Risks are not significant recorded 32.2% of the total chemicals assessed while none for insufficient chemical information and uncertain chemicals exposure recoded. There are several points of discussion for the CHRA assessment conclusion analysis from the Table2 and the findings were well aligned with structured interview. Based on the interview findings, several control methods are found to be not adequate in mitigating the risks.

It was also observed that no written Safe System of Work (SSW) in place. Safe system of work is defined as a formal safety operation procedure which results from systematic examination of a task in order to identify all the hazards. In terms of chemical health risk management, SSW is important as a communication tool so that workers are aware of good work practices and steps on how to effectively protect themselves from chemical exposure. Currently, there is no formal written SSW such as safe operating procedure or work instructions devised for every job tasks involved with handling or exposure to chemicals.

Furthermore, no testing and examination of water sprayer system at crusher section was observed. Water spraying or sprinkling system is a common method used as dust suppression technique in stone quarries. While regular inspection of the water spraying pipes is carried out to ensure they are not clogged, examination and testing of the system had not been conducted before. Due to that, the effectiveness of this system to control dust emission cannot be determined adequately. In this case the water spraying system need to be examined and tested by a competent person at minimum of 12 months' interval as stated in USECHH Regulations 2000 – Regulation 17.1.b

Inappropriate of personal protective equipment (PPE) was also observed during the inspection. The PPE provided to the workers is not suitable because they did not match with the type of airborne contaminants such as surgical mask used in prevention of dust are unable to filter dry dust and cotton glove was used in handling oils.

Table 2 Assessment Conclusion and Percentage Based on Quarry Operator

Quarry Operator	Assessment Conclusions: No. of Chemical, (%)				
	C1 Risk Not significant	C2 Adequate Control	C3 Inadequate Control	C4 Insufficient Information	C5 Uncertain Exposure
Operator 1	5	0	7	0	0
	(41.7)	(0)	(58.3)	(0)	(0)
Operator 2	6	1	3	0	0
	(60)	(10)	(30)	(0)	(0)
Operator 3	5	0	4	0	0
	(55.6)	(0)	(44.4)	(v0)	(0)
Operator 4	2	8	0	0	0
	(20)	(80)	(0)	(0)	(0)
Operator 5	5	0	4	0	0
	(55.6)	(0)	(44.4)	(0)	(0)
Operator 6	7	7	0	0	0
	(50)	(50)	(0)	(0)	(0)
Operator 7	1	3	16	0	0
	(5)	(15)	(75)	(0)	(0)
Operator 8	1	2	12	0	0
	(6.7)	(13.3)	(80)	(0)	(0)
Operator 9	0	9	0	0	0
	(0)	(100)	(0)	(0)	(0)
Operator 10	6	1	8	0	0
	(40)	(6.7)	(53.3)	(0)	(0)
Operator 11	12	15	0	0	0
	(44.4)	(55.6)	(0)	(0)	(0)
Operator 12	1	10	1	0	0
	(8.3)	(83.3)	(8.3)	(0)	(0)
Operator 13	3	3	3	0	0
	(33.3)	(33.3)	(33.3)	(0)	(0)
Total	**55**	**60**	**56**	**0**	**0**
	(**32.2**)	(**35.1**	(**32.7**)	**(0)**	**(0)**

Table 3 shows the result of control banding method for each chemical used in quarry while Table4 outline four basic levels of control bands. There were eight (8) chemicals categorized under hazard band E which is the most hazardous chemical hence require special control approach to handle this group of chemicals. Seven (7) chemicals were assessed with hazard band D and categorized with control approach 3 and control approach 2. The different in control approach for chemical in same group of hazard band depends on the amount of chemical exposed at the workplace. Table3 also shows nine (9) chemicals were assessed with hazard band C, one (1) chemical assessed with band B and ten (10) chemicals were assessed with hazard band A. Global Harmonize System (GHS) codes are used to categorize the hazard band between those chemicals used in quarry from extreme chemical to those chemicals at lower level toxicity. The chemicals with no H code means the hazard is categorized as non-hazardous chemicals. Those are chemicals with the lowest hazard band as suggested in COSH Essentials.

Table 3 Result of Hazard Banding for Chemicals Use in Quarry

Chemical	GHS Tier 1 Occupational Banding H Statement	Hazard Band	Control Band
Granite	H372, H350, H319, H335	E	Control approach 4
Limestone	H350, H373, H315, H319	E	Control approach 4
Welding fume	H302, H317, H350, H314, H351, H319, H335, H372	E	Control approach 4
Waste oil	H302, H315, H319, H332, H317, H340, H350, H360, H335, H336, H304, H371	E	Control approach 4
Asphalt	H319, H350, H361, H372	E	Control approach 4
Zinc dust	H315, H319, H302, H336, H334	E	Control approach 4
Repumpable matrix	H319, H350, H361, H372	E	Control approach 4
Cement	H314, H317, H335, H350	E	Control approach 4
Gear oil	H304, H315, H400, H361, H413	D	Control approach 3
Diesel	H332, H315, H351, H373, H374	D	Control approach 3
Emulsion explosive	H351	D	Control approach 3
Cyanide	H300, H310, H314, H315, H319, H330	D	Control approach 3
Methylene chloride	H315, H319, H302, H370, H335, H336, H351	D	Control approach 2
Ethyl alchohol	H226, H315, H319, H361, H336, H370	D	Control approach 2
Thiourea	H302, H315, H317, H351, H361	D	Control approach 2
Kerosene	H304, H315, H336, H335	C	Control approach 2
TMB power coolant	H373	C	Control approach 2
Chemicide 75	H302, H315, H318, H335, H400	C	Control approach 2
Bakelite powder	H318, H317	C	Control approach 2
calcium hidroxide	H315 ,H318, H335	C	Control approach 2
Sulfuric acid	H303, H314, H412	C	Control approach 2
Sodium cyanide	H301, H311, H332, H315, H319, H402	C	Control approach 2
Hydrochloric acid	H314, H318, H335, H302	C	Control approach 2
Nitric acid	H314, H318	C	Control approach 2
Ammonium nitrate	H319, H303, H272	B	Control approach 2
Acetylene	H220, H280	A	Control approach 1
Engine oil	H315, H319	A	Control approach 1
Grease	NA	A	Control approach 1
Compress oxygen	H270, H280	A	Control approach 1
Welding electrode	NA	A	Control approach 1
Hydraulic oil	NA	A	Control approach 1
Engine oil treatment	NA	A	Control approach 1
Glyphosate isopropylamine	H315, H318, H411	A	Control approach 1
Metsulfuron methyl	NA	A	Control approach 1
Bitumen	NA	A	Control approach 1

Table 4 Control Bands

Amount of the chemical present in the workplace at any one time				Control band approach	Recommended control measure
A little (g or mg)	Some (kg or L)	A lot (hundred of kg or L up to a few metric tonnes or cubic meter)	Bulk (many metric tonnes or cubic meter		
C	B	A	A	1	General ventilation, basic hygiene
D	C	B	A/B	2	Local exhaust, engineering control
D	D	C	C	3	Enclosure, containment, strict engineering control
		E		4	Special cases that require a professional evaluation

4.0 CONCLUSION

This study evaluates the findings of CHRA report from various quarry organizations, aiming to standardize on control measure in conducting CHRA at quarry industries via control banding method. Thirteen CHRA reports were analyzed and found that there are inconsistencies in rating the hazards by competent assessors. Most of the quarries are operating in inadequate control measure that could have effect on the health of the workers. From the analysis, it was found that only 32.7% of the chemicals are in adequate control.

There were eight chemicals categorized as hazard band E, seven chemicals with hazard band D, nine chemicals with hazard band C, one chemical with band B and 10 chemicals with hazard band A and assigned control approach 4 to control approval 1 based on an amount of chemical concentration.

Overall, the findings from this study will help assessors to improve the assessment result of CHRA in achieving adequacy of control of risk among workers in quarry industries. This will also make it easier to the operators to understand the associated risk and reduce the number of health disorders contributed by the quarry industry.

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Original Article

A Survey on Return to Workplace Measures During the Recovery Phase of COVID-19 Pandemic among Malaysian Corporate Health Advisers' Forum (MCHAF) Members

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ABSTRACT: *A survey was conducted among Malaysian Corporate Health Advisers' Forum (MCHAF) members to ascertain measures taken by their organizations during the recovery phase of COVID-19 Pandemic. All organizations fully complied with the mandatory requirements from the authorities for the workplace such as practice physical distancing, temperature screening, health declaration, use of face mask and enhance cleaning protocols. Most of the organization also instituted additional measures which were all aligned with the principle of facilitating reduction of COVID-19 transmission in the workplace.*

Keywords: *COVID-19, Health Adviser, Industry, Occupational Health, Return to Workplace*

1.0 INTRODUCTION

On 10th June 2020, the recovery phase of the Movement Control Order started in Malaysia, and most organizations were able to fully resume operations. However, they were required to follow Standard Operating Procedures (SOP) provided by the Malaysian Government.

The Guidelines on Management of COVID-19 in Malaysia by the Ministry of Health (MOH) Malaysia (Kementerian Kesihatan Malaysia, 2020c). has been a key reference document on managing the pandemic in the country. Annex 25 of this document provides management guidelines for workplaces which includes action by employers and employees, action at the workplace, and travel considerations for the workplace. Among the recommended actions at the workplace are regular disinfection, consider no handshaking policy, facilitate hand cleaning, contingency for limited human resource, alternative communication methods and avoiding large meetings especially if indoors.

The MOH Malaysia's COVID-19 Website (Kementerian Kesihatan Malaysia, 2020b) which contains important information on the pandemic also hosts SOPs on the Recovery phase (Kementerian Kesihatan Malaysia, 2020e). These SOPs were produced by various agencies including National Security Council, Ministry of Health Malaysia, PETRONAS, Ministry of International Trade and Industry and covered different sectors such as the healthcare, oil and gas, and manufacturing. These SOPs cover areas such as prevention and control protocols, health screening, health reporting, workplace disinfection, social distancing and worker's safety and health procedure, and etiquette in common areas in premises, office vehicles and use of MySejahtera application.

The Department of Occupational Safety and Health Malaysia, Ministry of Human Resources (MoHR), also produced an SOP for Prevention of COVID-19 at the Workplace (Jabatan Keselamatan dan Kesihatan Pekerjaan, Kementerian Sumber Manusia, 2020) which is applicable to all workplaces. However, it does not apply to "Work from Home" activities. The SOP defined the responsibilities of employers, coordinators, emergency response teams, supervisors and employees. The SOP provides recommendations on procedures before entering the workplace, temperature screening, general rules when at work and having meetings, handling emergency situation related to COVID-19 when at work, workplace disinfection, handling COVID-19 positive cases (for healthcare workers), personal protective equipment and training and control measures.

We were interested to find out what were the measures adopted by workplaces during the recovery phase of COVID-19 pandemic in Malaysia. This survey was conducted among members of the Malaysian Corporate Health Advisers Forum (MCHAF), an informal group of occupational health doctors and specialists in Malaysia who serve the various industries. Among the industries represented are aviation, chemical, electronic, healthcare, manufacturing, oil and gas, social services and utilities.

2.0 METHOD

In June 2020, all MCHAF members were invited by e-mail to respond to a brief online anonymous survey using SurveyGizmo on their return to workplace plans during the recovery phase of the COVID-19 outbreak in Malaysia. The survey form was developed by the authors based on what they felt were measures generally being considered by MCHAF members. Respondents were asked to answer 15 statements on workplace measures and provided with 5 answer options were 'implemented', 'considered', 'not considered', 'unsure' and 'others'. After analyzing the responses, the authors felt that it would be best to exclude one question which was confusing and to simplify responses into 3 categories instead of 5 and which were: 'implemented and 'considered; ' unsure' and 'others' and; 'not considered'.

3.0 RESULTS

3.1 Respondents

Thirty out of 50 MCHAF members (60%) were participated in the survey.

3.2 Responses

Almost all (80-100%) of the organizations have implemented or were considering: physical distancing at the workplace (100%); preventative controls at workplace, i.e. temperature screening/health declaration (100%); encourage use of mask at workplace or on public transport (100.0%); enhanced cleaning protocols (100%); special arrangements for those in with comorbidities/high risk group (93.3%); a contingency plan in the event of a second wave of the COVID-19 pandemic (93.3%); flexible work hours including work from home (WFH) (93.3%); create contact tracing methods within the workplace (90.0%); changes to food and catering services (90.0%); enhanced psychological support (90.0%); provide masks for daily use when coming to the workplace (86.7%); and modification of its Medical Emergency Response due to the change of risk appetite of community transmission - mild respiratory symptoms suspected to be COVID-19 (80.0%). Most organizations (50-79%) have implemented or were considering: provision of ergonomic equipment and/or IT equipment for those working from home (70.0%); and changes of Human Resource (HR) policies and employee benefits (63.3%) Table 1.

Table 1 Measures Implemented or Being Considered by Organizations During The COVID-19 Recovery Phase in Malaysia

Question	Number and percentage			
	Implemented /considered	Not Considered	Unsure/ Others	Total
Has your organization implemented physical distancing measures at the workplace (workstations, common areas etc.)?	30(100%)	0(0%)	0(0%)	30(100%)
Has your organization implemented preventative controls at the workplace (daily temperature screening/ health declaration)?	30(100%)	0(0%)	0(0%)	30(100%)
Does your organization encourage use of face masks at the workplace and/or on public transport?	30(100%)	0(0%)	0(0%)	30(100%)
Has your organization implemented enhanced cleaning protocols (regular cleaning of frequently touched surfaces)?	30(100%)	0(0%)	0(0%)	30(100%)
Does your organization have special arrangements for those with comorbidities/high risk group (flexible hours/ WFH)?	28(93.4%)	1(3.3%)	1(3.3%)	30(100%)
Does your organization have a contingency plan in the event of a second wave of the COVID-19 pandemic?	28(93.4%)	1(3.3%)	1(3.3%)	30(100%)
Does your organization have more flexible work hours for all including WFH option?	28(93.3%)	0(0%)	2(6.7%)	30(100%)
Has your organization created contact tracing methods within the workplace (apps, attendance registration etc.)?	27(90%)	3(10%)	0(0%)	30(100%)
Has your organization made changes to its food and catering services (e.g. promote in-house meals, modified guidelines for food handlers, avoid going out for meals/ lunch)?	27(90%)	3(10%)	0(0%)	30(100%)
Has your organization provided enhanced psychological health support (e.g. extending Employee Assistance Program (EAP) to family, increased focus on mental health programs etc.)?	27(90%)	2(6.7%)	1(3.3%)	30(100%)
Does your organization provide face masks for daily use when coming to the workplace?	26(86.7%)	1(3.3%)	3(10%)	30(100%)
Has your organization modified its Medical Emergency Response due to the change of risk appetite of community transmission-mild respiratory symptoms suspected to be COVID-19 (e.g. creation of isolation room, refresher for first-aiders specific to COVID-19 response etc.)?	24(80%)	2(6.7%)	4(13.3%)	30(100%)
Does your organization have provision of ergonomic equipment (tables, chairs) and/or IT equipment (monitors, keyboards) for those WFH?	21(70%)	6(20%)	3(10%)	30(100%)
Has your organization made changes to HR policies and employee benefits (e.g. leave management - given more leave days or carry forward to next year, flexi allowances - internet fees reimbursement etc.)?	19(63.3%)	7(23.3%)	4(13.3%)	30(100%)

4.0 DISCUSSION

Risk Assessment needs to be done at workplaces to ensure that appropriate control measures can be instituted to prevent COVID-19 transmission in the workplace (Jabatan Keselamatan dan Kesihatan Pekerjaan, Kementerian Sumber Manusia, 2020). Based on the variety of responses from organizations surveyed on certain measures, it appears that they have performed risk assessments to determine what measures are most relevant to them.

All organizations fully complied with commonly recommended measures at the workplace such as physical distancing, temperature screening or health declaration, use of masks and enhanced cleaning protocols. Almost all or most organizations had implemented or considered measures that would either directly or indirectly prevent COVID-19 transmission at the workplace or its impact.

Older adults and people with underlying medical conditions such serious heart disease, immunocompromised state or type 2 diabetes mellitus are at risk of severe illness when infected with COVID-19 (Centres for Disease Control and Prevention, 2020b). Instituting measures such as working from home and flexible work hours reduces employees' exposure to crowds either while traveling to work or in public areas and hence would help to reduce the risk of disease transmission and impact to employees and their organization.

The second wave theory arises from the 1918 to 1920 'Spanish Flu' experience where after the initial outbreak, a deadlier strain emerged. There has been concern that the COVID-19 may also show a similar trend (Centre for Evidence Based Medicine, 2020). Hence while in some countries there seems to be a reduction in numbers of new cases, there is a possibility that new cases may rise again and be more severe. Almost all organizations in this study already have pandemic plans which were either generic or specific to cover for such situations.

Contact tracing is an important measure to contain outbreaks (Centres for Disease Control and Prevention, 2020a). Almost all organizations have determined their method to trace close contacts at the workplace. Since many people now have mobile devices, the use of mobile application is one convenient way of identifying close contacts of cases. A commonly used application which is promoted by the Malaysian Government is MySejahtera application (Kementerian Kesihatan Malaysia, 2020a).

It is also important to maintain physical distancing when eating, drinking or during rest breaks to prevent COVID-19 spread. Hence it is expected that organizations would review such arrangements at the workplace to ensure this can be achieved.

Due to the impact of COVID-19, i.e. fear and significant change to our lives, it is especially important to look after mental health during the pandemic (World Health Organisation, 2020). MOH has recommended mental health assessments be carried out among employees and appropriate measures to reduce stress among employees be taken (Kementerian Kesihatan Malaysia, 2020c). Almost all organizations in this study have enhanced psychological support to their employees.

Employees in Malaysia are encouraged to use face masks at the workplace (Kementerian Kesihatan Malaysia, 2020d). During the initial phase of pandemic there was difficulty obtaining masks in the market. In such situation some employers tried to procure masks in bulk and supply to employees especially to those who were required to come to the workplace. At present, face masks are easily available in the market and some employers feel that it is reasonable for employees to purchase their own masks as needed.

Since it is well established that people with no or mild symptoms may still transmit the disease, most organizations have enhanced their Medical Emergency Response plans to mitigates this.

Although not specifically recommended by MOH or MoHR, most organizations have decided to provide their employees with ergonomics or IT equipment for those working from home and/or changed their HR policies and

benefits in response to the COVID-19 pandemic. These measures are to help employees perform at their best at home where they are expected to continue delivering their work responsibilities.

5.0 CONCLUSION

While all companies have complied with the mandatory requirements by the authorities, MCHAF members have conducted risk assessment at their workplace and implemented or considered numerous additional measures for return to work during the recovery phase of COVID-19 pandemic in Malaysia. These methods are meant to better support employees and provide more robust controls in limiting the spread of COVID-19 within the workplace.

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Original Article

Evaluation of Process Safety Management Implementation in an Oil Field Services Company

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ABSTRACT: *Serious injury and fatality incidents are frequently occurring in the oil and gas industry due to high risk operations. Process Safety Management (PSM) is a management system that is attentive to the prevention, preparedness, mitigation, response and restoration of energy release from process in a facility. Despite the fact that company A has a comprehensive PSM system in place, its pipeline services division suffered a fatality and a loss time injury incident in eight months gap for its global operation. The purpose of this study is to evaluate the knowledge of employees on PSM by conducting a survey and by auditing the implementation of PSM by division of pipeline services. Cause mapping was used to analyse the contributory causes of PSM implementation. The results of survey show that 50% of the questions were answered correctly by 59 respondents in knowledge session, low communication level and moderate implementation level of PSM. The findings of the audit conclude that PSM has been partially implemented in operation. The contributory causes of partially implemented PSM are due to no enforcement from headquarters, improperly rolled out and ineffective PSM programme training, no legal and client requirements on PSM in Malaysia, and high implementation costs. Improved implementation of PSM could reduce the rate of incidents in the future.*

Keywords: *Cause Mapping, Oil and Gas, Process Safety Management, PSM Audit*

1.0 INTRODUCTION

Many chemical processing plants were constructed in 1950 during the industrial revolution to satisfy the industrial needs through the use of machinery for replacing work by hand at home. Since 1984, however, numbers of safety disasters have continuously occurred in close gap due to insufficient preventive measures (Long, 2009). Incidental disasters such as the 1984 Bhopal disaster in India caused thousands of deaths and the 1989 explosion in Pasadena, Texas caused 23 deaths. (Pasman, 2015). In 1976, a dioxin contamination from runaway reaction at Seveso, Italy led to serious environmental consequences where nearly 81000 animals died (Fabiano et al., 2017). China Tianjin's explosion of ammonium nitrate in 2015 resulted in 173 deaths due to improper storage (Huang & Zhang, 2015). Qingdao, China's pipeline explosion in 2013 and Kaohsiung, Taiwan's gas explosion in 2014 share similar causes where hydrocarbon leakage from underground pipelines to municipal drainage systems resulted in vapor cloud explosions (Halim & Mannan, 2018).

In the wake of these disasters, Occupational Safety and Health Administration from United States introduced Process Safety Management which is regulated under Process Safety Management Standard, 29 CFR 1910.119, titled Process Safety Management of Highly Hazardous Chemicals in the year of 1990 and it was enacted in 1992 (Long, 2009). The process safety management system consists of 14 elements and its intention is to prevent the occurrence of major incident such as explosion, fire and toxic release (Mohd Shariff et al., 2016).

According to a study conducted in South Korea's chemical industry, it found that the incident rate of fatality, injury and near miss have been reduced by 62%, 58% and 82% respectively after 7 years of implementation in PSM (Kwon, 2006).

Number of hazards are involved during the maintenance of oil and gas pipeline due to the interface of numerous risk factors such as personnel, environment and equipment (Yu et al., 2018). Pipeline's servicers are possible to have fatal injury during pipeline construction, assemble and inspection operation with the condition of their presence and incident event will match (Vtorushina et al., 2017). The major risk found in their operation is high pressure. A Safety and Health Information Bulletin was shared by United States Department of Labor (2004), two workers were killed during testing operation process of the pipeline, they got struck by temporary de-watering piping due to excessive air pressure in the line. As reported by newspaper, two workers got killed and one hurt during a pipeline maintenance work at South Texas Pipeline due to sudden release of 800 pounds of pressure ("2 Workers Killed", 2016).

Company A is an oil and gas service provider to major operators and headquarters in the United States. They have a division of pipeline services that deals with high pressure in their job activity. Although there was a comprehensive process safety management system in place, in an 8-months gap, the pipeline services division had 1 fatality and 1 time injury loss incident. In this study, survey study, audit and cause mapping was conducted to evaluate the implementation of process safety management in Company A's pipeline services division.

2.0 METHOD

In this study, three methods were conducted to evaluate the implementation of PSM of Company A's pipeline division, which are survey, audit and cause mapping.

2.1 Survey

The survey was conducted to find out the level of communication of PSM in the knowledge of the pipeline services division of employees in PSM and the implementation of PSM in their daily work activities. The questionnaire consists of 5 Likert Scale styled questions and multiple choices. The similar 5 Likert Scale styled questionnaire survey was also practiced by Tang et al. (2017) study on Factors Affecting Safety of Processes in the Malaysian Oil and Gas Industry. Developed questionnaire was distributed to 10 employees who are excluded from the targeted study group and improvements were made during the pilot study. The Cronbach's α obtained is 0.829, which is more than 0.80, indicating that the items show good internal consistency (Rattray & Jones, 2007). Based on the calculation using the formula of Krejcie and Morgan as shown in equation 1 below, the sampling size determined for this study is 59 based on the confidence level is 95% and the population is 70. Inferential statistics will be at 0.05 significance level (Walters et al. , 2017).

$$S = X2NP\ (1-P)/\ d2\ (N-1) + X2P(1-P) \quad \text{(Eq.1)}$$

The finalised questionnaire consists of a total of 30 questions distributed to 59 employees of the pipeline division who work on the operation site using a simple random sampling method. The data collected from questionnaires were then analysed using IBM Statistical Package for Social Scientists (SPSS) Statistics 21.0.

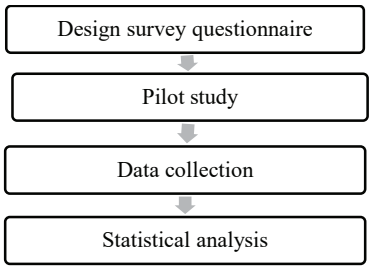

Figure 1 Flowchart of Methodology for Survey Study

Table 1 Rating Based on Mean Score

No.	Mean Value	Rating
1	1.00 – 2.33	Low
2	2.34 – 3.67	Average
3	3.68 – 5.00	High

2.2 Audit

An audit was conducted on the division of pipeline services based on the process safety management procedure of the company to evaluate compliance with the process safety management system of Company A. A robust audit programme involves management representatives and subject matter experts to ask questions on site (Rains, 2009). The audit was divided into three main parts which are reviewing evidence and documentation, interview field employees and site inspection (Norozi et al., 2013). As mentioned earlier, the audit conducted was only focus on elements fall under category of managing risk based on Company A process safety management system. Therefore, the gap analysis of process safety management implementation and its company system was identified based on the audit results. An audit checklist on the implementation of PSM was drawn up based on the Company A PSM procedure. Score for implementation compliance was given to each audited elements and sub-elements, ranging from 1 to 4 where 4 is fully implemented. Table 2 and 3 below shows the scores that indicate the compliance.

Table 2 Audit Scoring and Indicator

Scoring	Indicator
1	Awareness
2	Partial Implementation
3	Implemented but Needs Improvement
4	Fully Implemented

The total scoring of all elements is summed up and divided into total elements in order to obtain the final level of compliance to answer Objective 2 for this study. This audit checklist contains a total of 32 sub-elements based on Company A process safety management procedure.

Table 3 Scoring for Audit Implementation Level

Scoring	Implementation Level
1-1.9	Awareness
2-2.9	Partial Implementation
3-3.9	Implemented but Needs Improvement
4	Fully Implemented

2.3 Cause Mapping Analysis

Cause mapping analysis was also being conducted in this study, the outcome from survey study and audit were used to analyse the causes of implementation level of process safety management for pipeline services division. By using cause mapping, topics and their related causes could be bring together into hierarchical trees by asking "why" to sort problems from their root causes(Wagner, 2012). Thierry et al. (2017) has also applied cause mapping method to identified the root cause of ineffective and inefficient healthcare technology management in their study.

3.0 RESULTS AND DISCUSSION

3.1 Survey

3.1.1 Demographic

Based on the demographic data collected for this study, 12% of the 59 respondents are aged 21 to 30 and 78% are aged 31 to 40. Furthermore, 7% of them are between 41 and 50 years of age and the remaining 3% are over 50 years of age. Most respondents are between the ages of 31-40. Because of this company's minimum hiring requirement, all respondents will have at least 'Sijil Pelajaran Malaysia' SPM or Malaysian Education Certificate. SPM is a national examination taken by all fifth form secondary school students in Malaysia. 51% of the respondents are having SPM, 14% are having diploma certification and 36% are having certification in Bachelor Degree. Company hiring requirement for an operator's position is to require a minimum SPM level and a Bachelor's level for an engineer's position. Of the 59 respondents, 36% are engineers and 64% are operators. Due to job and contract requirements, the number of operators is always more than engineers. Engineer assigned as a project lead on site and operators are more towards to hands on skill job. According to the questionnaire received, 12% of the respondents have less than 3 years of working experience in this Company and 37% of them have being with this Company for 4 to 6 years. In addition, 42% of the respondents have 7 to 9 years working experience with this Company and only 9% of the respondents have been working with this Company for more than 9 years.

3.1.2 Communication Level of PSM

Table 4 Descriptive Data for Communication Level of PSM

No	Questions	N	Mean	Communication Level of PSM
Q5	I'm knowledgeable in Company's PSM	59	2.2373	Low
Q6	I have received PSM related training provided by company	59	2.0508	Low
Q7	My N+1 / PM /PL always educate and remind me about PSM	59	2.1695	Low
Q8	I received PSM related information / memo or email circulation frequently from company	59	1.9322	Low
Q9	I understand every clauses in Company PSM procedure	59	1.9153	Low
	Valid N (listwise)	59		
	Average		**2.0610**	**Low**

Table 4 above shows that this section contains a total of 5 questions and 59 respondents have answered them. The mean value obtained Q5 is 2.24, Q6 is 2.05 and Q7 is 2.17. However, there is an even lower mean value found for Q8 and Q9 which is 1.93 and 1.91. The results obtained for each questions are low level of PSM communication, thus, the average result obtained for this section is also low communication level As a result, it shows that superiors are not committed to cascading PSM-related information to their employees, which causes employees not to be trained with PSM knowledge Email circulation is the easiest way to communicate in Company A because all employees have access to corporate email and intranet, but the resources are not being used.

3.1.3 Knowledge level of Employees' on PSM

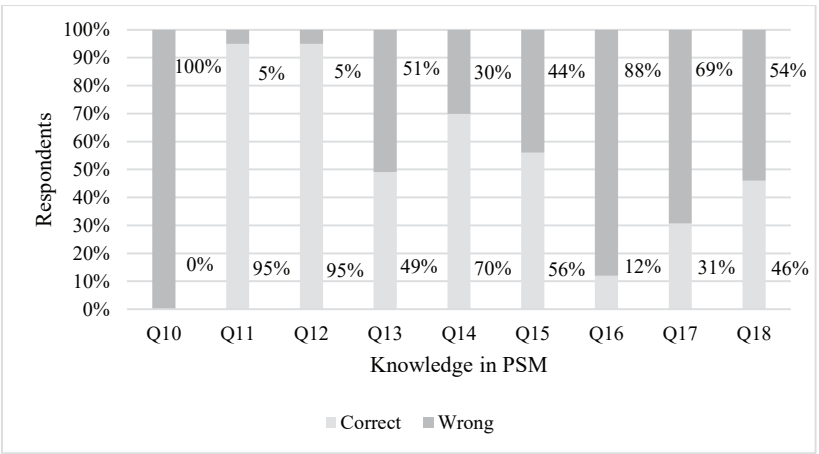

Figure 2 Result for Q10 to Q18, Percentage of Correct and Wrong Answer Provided by Respondent

Fig. 2 shows the percentage of respondents correct and incorrect response through survey questionnaires. Based on the questionnaire analysis for this section, none of the respondents had obtained 100% correct answers to all these questions they had answered during the training. The total elements found in the Company's process safety management system in Q10 could not be remembered by all respondents. However, in Q11 and Q12, 95% of respondents are able to respond to the basic principles of process safety. And, despite multiple choices in Q13, 51% of respondents were unable to define what process safety incident is.

With the percentage of 70% and 56% respectively, more than 50% of respondents able to answer Q14 and Q15 which are process safety barrier related questions. In Q16, a total of 88% of respondents were unable to obtain the correct response to the BowTie risk assessment method. And in Q17, 69% of respondents were unable to remember the total number of Critical Upstream Process Safety Requirements. 54% of respondents do not know what the process safety risks are for their job nature for the last question in this knowledge test session.

Table 5 List of Questions for Q10 to Q18

No.	Questions
Q10	How many elements found in Company Process Safety Management System?
Q11	Upstream Process Safety is
Q12	Personal safety focuses on individual behaviour whereas process safety focuses on equipment, process and people
Q13	Process Safety Incidents are of:
Q14	What method helps determine barriers to protect the top event from occurring and minimize consequences?
Q15	At our company, what are considered as barriers to prevent process safety incident from occurring?
Q16	The BowTie Risk Assessment method has the following key elements EXCEPT:
Q17	How many Critical Upstream Process Safety Requirements are there in Company?
Q18	The following are Process Safety Risk for our division EXCEPT?

There are several possible reasons of respondents unable to answer those questions in questionnaire which are they do not implement process safety management system after the taken the training, thus, the knowledge is fading away with time. Secondly, there is no refresher training needed for this training course, thus, respondent might sat for the training many years ago as the majority of the respondents are having working experience from 4 to 9 years based on the demographic data obtained from this survey. As mentioned by Sutton (2015), training has to be an on-going process due to employee's performance will be declining if there is no further training is carried out. Thirdly, company PSM training was conducted through online, thus, employee is able to seek for co-worker assistance to answer exam question in the training module.

3.1.4 Implementation level of PSM

Table 6 Descriptive Data for Implementation Level of PSM

No.	Questions	N	Mean	Implementation Level of PSM
Q19	Current project SOP cover PSM	59	2.3220	Low
Q20	Project induction covers PSM topic such as operating procedures, ERP, MOC and etc.	59	3.4915	Average
Q21	Fully utilized all the PSM related document which are made available in company online database	59	2.6780	Average
Q22	Fully utilized the BowTie risk assessment for my division which is made available in company online database	59	2.0169	Low
Q23	Documentation outlining the protective systems installed to prevent process safety related incidents	59	3.5085	Average
Q24	Utilized BowTie risk assessment or an alternative method such as hazard risk assessment to review process safety risks prior project started	59	3.9831	High
Q25	Select the right barriers for the hazards and risks	59	3.5085	Average
Q26	Active monitoring of barriers strength	59	2.8475	Average
Q27	All the safety equipment/ barriers such as pressure relief devices, pressure control equipment and etc. are always in use during operation	59	3.8305	High
Q28	Safety instrumentation and alarms such as emergency responses systems, alarms and sensors are in use during operation	59	2.7627	Average
Q29	A copy of project ERP in made available on site	59	2.8305	Average
Q30	MOC is always being raised when there is any deviation from procedure	59	3.1356	Average
	Valid N (listwise)	59		
	Average		**3.0763**	**Average**

There were 12 questions in this section based on Table 6, and all respondents have answered them. Out of 12 questions, 2 obtained a mean value of less than 2.33 indicating the low level of implementation, 8 achieved the mean value between 2.34 and 3.67 indicating the average level of implementation and 2, the mean value reached more than 3.67 indicating high level of PSM implementation. which is not fully complied with Company's process safety management system requirement. The total mean value for this questionnaire section shows the average level of implementation of process safety management in the division of pipeline services that is not fully compliant with the requirement of the Company's process safety management system. The result obtained is an average level of implementation may be due to employees not being aware of the requirement of company PSM or negligence due to no superior enforcement. A study found that Malaysians still lack understanding and implementation of PSM and not many PSM experts are available in Malaysia (Abu Bakar et

al., 2017). Unlike other countries such as the United States, the United Kingdom, Japan and Singapore, Malaysia still does not have a good approach to manage PSM.

3.2 Audit

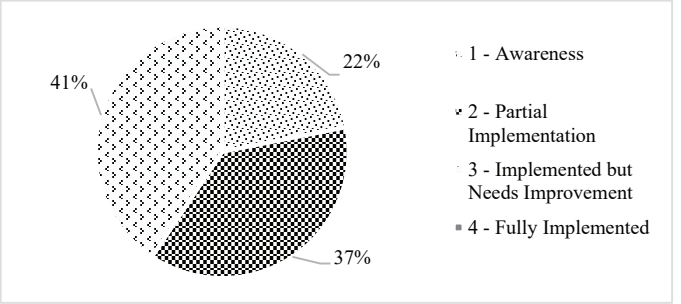

Figure 3 Overall Audit Result

Table 7 Audit Scoring

No.	Audit Element	Mean	Implementation Level
1	Operating Procedure	2.6	Partial Implementation
2	Asset Integrity and Reliability	2.6	Partial Implementation
3	Operation Management	2.7	Partial Implementation
4	Management of Change	1.4	Awareness
5	Human Factors	2.0	Awareness
6	Emergency Management	1.3	Awareness
	Average	**2.1**	**Partial Implementation**

Based on Fig. 3, there are 7 findings of awareness which is 22% of the total scores, 12 partial findings of implementation which is 37% of the total scores, 13 implemented but needs findings of improvement which is 41% of the total scores, 0 findings on fully implemented. Referring to Table 7, the audit checklist contains 6 elements, 3 of 6 elements found partially implemented, and 3 of the elements found during audit only at the level of awareness.

Operating procedure is retrievable on site during the interview session and engineers are aware of the latest revision of the operating procedure. However, most operators haven't seen the procedure and don't know the latest revision number. This is because engineers are accessible to the company's project server but not accessible to operators. This may cause miscommunication if any member of the team refers to the obsolete procedure during job execution and it has the possibility of causing an incident if the operator operates the equipment at the wrong working pressure.

During the audit, testing and calibration certificates are found on site, but feedback from the team is that they experienced equipment breakdown during the operation. Although the calibration and maintenance of the equipment is performed in conjunction with the issuance of the certificate prior to mobilisation, it is performed only by the employee of the company, not by the competent person from third party service provider. This may affect the quality and reliability of the equipment's calibration and maintenance. All the equipment came along with on-site testing and maintenance certificates, but some small items such as hose and sling certificates are not found on-site.

The operation management execution plan was found to focus solely on equipment, process and staff management during operation, not much information was provided on staff competency, human factors and compliance with laws and regulations. Risk assessment was not carried out in a team of subject matter experts from the relevant department, but individually based on the interview session. Risk assessment should be conducted with participation of relevant department's representative, is a group-based approach, not individual approach (Ayres & Parra, 2016). Yet, the risk assessment has been discussed together with client during the HAZID session prior mobilization. The competent management program was found not in accordance to company's requirement,improper and ineffective competency management program practice might lead to incident happen due to employees do not know how to operate the equipment safely.

Based on the audit interview session, MOC was not raised for minor process and equipment changes such as increased operating pressure and changes in the type of hose used. However, risk assessment was not conducted for the raised MOC, but only fill out the MOC form. No evidence of toolbox talk or meeting attendance list found for communication of MOC raised. The MOC process only involved engineer and client in charge but not the operator, operators are not aware of the MOC raised during interview session.

The 24 hours operation is run by 2 shifts of employees and each shift works 12 hours. Employees are given sufficient rest time to avoid fatigue. However, it was found that the work load on engineers are over burden which caused them do not have sufficient rest time as they are the overall person in charge in the project where they have to deal directly with the working team and client. This cause insufficient rest and increased in stress level to the engineer, and might lead to wrong decision making during the project execution due to fatigue.

During the audit, project specific emergency response plan is not available but employees have undergone site orientation conducted by client. In case of emergency, client will be the incident commander due to they are the site owner. Employees participated in facility's emergency drill which is conducted by client which participation is mandatory. On the other hand, there is no emergency drill conducted by Company project team. Risk-based contingency planning shall be performed and implemented as required and follow Company's global contingency planning processes. Yet, the contingency plan is not found or implemented on site.

3.3 Cause Mapping Analysis

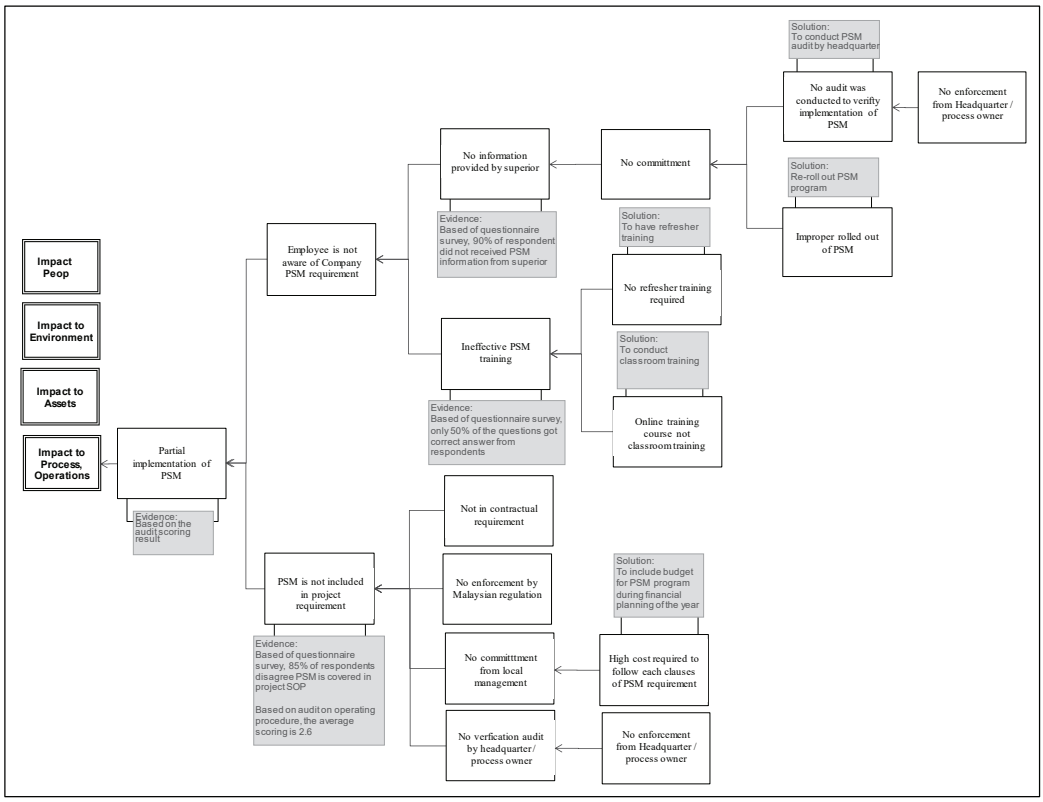

Figure 4 Cause Mapping Analysis

There are few root causes to be identified based on the cause mapping analysis in Fig. 4. One of the causes of partial implementation of PSM is that employees are not aware of the company's PSM requirement because no information is provided by their superior, which is obtained from the survey findings of the questionnaire, 90% of respondents said they did not receive PSM related information from their superior. This shows that lack of commitment to PSM by superior, and the possible cause is that no PSM verification audit was conducted by headquarters or process owner. And another possible reason is improperly rolled out of PSM where employees and superiors do not know their role and responsibility in PSM. Internal audit is necessary to be conducted to ensure system is in place and implemented effectively, issues are identified before it being identified by customer or legal authority (Swainson, 2018).

Another cause of employees being unaware of the company's PSM requirement is that ineffective PSM training was provided to employees due to online training and no refresher training required. A study found that students unable to speak out their thoughts and ideas while doing online course and them feeling lost in the cyberspace (Mansour & Mupinga, 2007). On the contrary, students able to ask question and additional input with the physical presence of teacher in the classroom (Mansour & Mupinga, 2007).

Another reason why Company A pipeline services partially implement PSM is that PSM is not included in the project requirement. This is because PSM is not listed by the customer under contractual requirement and does not cover any of the regulations of Malaysia. Implementation of PSM in Malaysia is purely based on company's initiative (Abu Bakar et al., 2017). In addition, there is no commitment from local management, this might be due to high cost required to implement each clauses of Company PSM procedure. Last but not least,

there is no verification audit by headquarter or process owner, thus, local team may just skip the tedious process of implementing PSM.

Cause mapping in Fig. 4 analysed the contributory factor or root cause of the Company's pipeline services division partial implementation of PSM in order to respond to Objective 3 of this study. The possible root causes are no enforcement from headquarters, which is also the process owner, improperly roll-out of the process safety management programme, ineffective process safety management training, no legal and customer requirements for process safety management in Malaysia and high implementation costs.

4.0 CONCLUSION

In the wake of disaster incident and enforcement by United States OSHA department, numerous companies have started to implement process safety management system in their organization. Based on the results obtained from questionnaire conducted in this study, the communication level of process safety management in pipeline services division of Company A is low, only 50% of the questions got answered correctly by a total number of 59 respondents and implementation level of process safety management is moderate. From the result obtained from audit, it also indicates that implementation of process safety management by pipelines services of Company A is only partial implementation. The root causes of failure to fully implement the process safety management system found in this study are no enforcement from headquarters that is also the process owner, improperly rolled out of the process safety management programme, ineffective process safety management training, no legal and client requirement for process safety management in Malaysia, and high implementation costs.

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Original Article

The Relationship between Safety Behaviour and Safety Climate among Firemen

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ABSTRACT: *The study investigated the relationship of safety climate and safety behaviour among firemen in Selangor, Malaysia. Safety climate was measured in terms of employee perceptions for occupational safety and health management, safety communication, safety standard and goal, and individual involvement in their organization. Using a cross-sectional survey design, 150 firemen completed the questionnaire on safety climate and safety behaviour. Descriptive analysis and Pearson's correlation test were used to identify the significant relationship between variables. The analysis found that there was a significant relationship between safety climate and safety behaviour among firemen. There was a positive correlation of safety climate factors of communication ($p < 0.05$), safety standard and goal ($p < 0.05$) and individual involvement ($p < 0.05$) towards safety behaviour. Hence, the results indicated that the more positive safety climate is viewed, the more likely the firemen to practice the safety behaviour in job duties. In conclusion, this study can serve as the baseline for the management to prioritize the safety and health issue in the department and continuously improved their strategies to ensure the safety, health and well-being of the firemen in the organization.*

Keywords: *Firemen, Occupational Safety and Health Management, Safety Behaviour, Safety Climate*

1.0 INTRODUCTION

Safety refers to the state of being safe and protected from any harms. In specific, the workplace safety is concerned on the protection of health from any exposures to potential hazards. As the organization is expanding, the workplace safety become vital, as it may affect the competitiveness and corporate image to the society (Hamalainen et al., 2009). The conventional safety program only emphasized on the technicality and obligation to comply with safety regulations. The necessary mitigation measures are taking place when the

accidents have occurred (Garcia et al., 2002). Also, the rigid version of safety management program is always isolated and not integrated with other organizational functions.

The term of safety climate is about the assessment on molar perceptions among employees shared about their working environments. The criteria of safety climate may diverse, as such, their roles and responsibility on workplace safety, ability to communicate safety issues, accident reporting and safety reward systems (Zohar, 2000).

Meanwhile, the term of safety behaviour refers as the way and adherence to the established safety practices and procedures. In addition, safety behaviour can be affected and influenced by the safety climate in which firemen is immersed (Szubert and Sobala, 2002).

As the firemen tasks are hazardous and most of the hazards are difficult to remove, therefore it is important to make it as safe as possible (Walton et al., 2003). Researchers suggested that the fire service is one of the most hazardous industries based upon work-related injury rates (Bos et al., 2004). Since the hazards of firefighting cannot be removed, investigating the safety climate and safety behaviours among this population may help in forming necessary safety and risk reduction plans by addressing those controllable behavioural factors (Freaney, 2011).

In addition, the main duties of a firemen include responding to fire emergencies, oil spillages, accidents and various disaster responses. With that nature of job, it may expose the firemen to unexpected environmental stressors, heavy physical workloads, exposure to toxic agents and potential to obtain psychosocial hazards. It may have generated several health impairments such as injuries, traumas, respiratory diseases, cardiovascular diseases and cancers (Szubert and Sobala, 2002).

Many of the on-job accidents among the firemen happened due to the factors including problem in decision making, lack of communication and situational awareness, standard operating guidelines or protocol breach, and human error. Due to that condition, an effective safety climate practices are important to be implemented by the management in order to address human behavioural approach towards safety issues in their organization (Pedro et al., 2003). Recent research had highlighted that the safety climate can be used as a leading indicator to identify several safety-related issues of work organization (Nuruzzakiyah et al., 2019).

Thus, the purpose of this research is to investigate the relationship between organizational safety climate and safety behaviour. In addition, it will highlight the importance of establishing good organizational safety climate as the tool to encourage the enhancement of safety behaviour among the firemen.

2.0 METHOD

The research was a cross-sectional study conducted at two fire stations in Selangor, Malaysia. These fire stations were chosen based on the consideration of two factors; research timeline and approval from the respective Heads at the fire stations. The total population is approximately around 170 staff. For this research, a total of 150 firemen were managed to be employed as the respondents (Gill et al., 2010; Hamed, 2017).

A series of questionnaire was developed and scored based on the answers given by the respondents. The self-administered questionnaire consists of the socio-demographic of the respondents, safety climate survey (Cheyne et al., 1998) and safety behavior questions (Burke et al., 2008). The reliability test was conducted through Cronbach's alpha to determine on the internal consistency for each factor.

For the purpose of this study, the safety climate section consists of 18 questions based on 4 factors that rated on a Likert-type scale of "1 as strongly disagree" and "5 as strongly agree". The four-safety climate factor examined were (i) occupational safety and health management, (6 questions) (ii) safety communication, (5 questions) (iii) safety standard and goal, (2 questions) and (iv) individual involvement, (5 questions). Meanwhile, the safety behavior section contains 10 questions rated on a Likert-type scale of "1 as strongly disagree" and "5 as strongly agree".

The data collected were analysed by Statistical Package for the Social Science (SPSS). Descriptive analysis statistics was used to measure the means and standards deviations. Pearson's correlation coefficients tests were obtained to evaluate the relationship between safety climate and safety behaviour among firemen. This test is known as the best method of measuring the relationship or association between two variables (Harry, 2008).

3.0 RESULTS

3.1 Socio-Demographic Data

Table 1 presents the socio-demographic of the respondents. 81.3% of them were male and majority attained the highest education background at high school level. The data of education background is essential as the highest qualifications they achieve, the easiest they could to adhere to safety rules and regulations. It is due to their ability to digest and comprehend knowledge (Vinodkumar and Bhasi, 2009).

Table 1 Socio-Demographic Data

Variables	Category	Frequency (%)
Gender	Male	122 (81.3)
	Female	28 (18.7)
Race	Malay	127 (84.7)
	Chinese	0 (0)
	Indian	2 (1.3)
	Others	21 (14)
Academic Background	High School	116 (77.4)
	Diploma	17 (11.3)
	Degree	11 (7.3)
	Others	6 (4)

N=150

3.2 Reliability Analysis

Table 2 presents the value of Cronbach's Alpha for each variable in this study. The reliability of a research is recommended of at least 0.7 or above (Cronbach, 1990).

Table 2 Reliability Test

Measurement	Cronbach's Alpha
Occupational safety and health management	0.821
Communication	0.839
Safety standard and goal	0.783
Individual involvement	0.811
Safety behavior	0.708

3.3 Pearson's Correlation

Pearson correlation coefficient test is used to investigate the strength of relationship between safety climate factors and safety behaviour. The value of Pearson correlation coefficient (r) is ranged from -1 to +1. A positive value indicated a positive relationship and via versa (Weiers, 2008). The strength of correlation could be interpreted as suggested by Evans (1996) as shown in Table 3.

Table 3 Interpretation of Pearson's Correlation

R	Strength
0. – 0.19	Very weak
0.20 – 0.39	Weak
0.40 – 0.59	Moderate
0.60 – 0.79	Strong
0.80 – 1.00	Very strong

3.4 Correlation between safety behaviour and safety climate

Table 4 Correlation of Safety Climate Factors and Safety Behaviour

Safety Climate Factors	Mean (SD)	R	p-value
Occupational safety and health management	4.29 (0.75)	0.30	0.01**
Safety communication	4.36 (0.58)	0.43	0.01**
Safety standards and Goals	3.99 (0.81)	0.32	0.01**
Individual involvement	4.56 (0.54)	0.45	0.01**

***significant at p <0.05 level*

Table 5 Correlation Coefficient Ranking

(1)	Individual Involvement
(2)	Safety communication
(3)	Safety standards and Goals
(4)	Occupational safety and health management

(1) – The highest coefficient (r)

From Table 4 and 5, it is found that all safety climate factors were positively correlated with safety behaviour. Based on the interpretation in Table 3, safety climate factor on "Individual Involvement" was positively and moderately correlated with safety behaviour with correlation coefficient of 0.45. Other factor, "Safety communication" was positively and moderately correlated with safety behaviour with correlation coefficient of 0.43. However, "Safety standards and Goals" was found positive but weakly correlated with safety behaviour with correlation coefficient of 0.32. As well as, the factor of "Occupational safety and health management" was found positive but weakly correlated with correlation coefficient of 0.30.

4.0 DISCUSSION

Individual involvement in safety initiatives such as participation on safety training at the workplace may result in positive outcomes on safety behaviour and safety performance. A study has highlighted that the target of safety training is to prevent any workplace injuries (O'Toole, 2002). The participation in safety training may encourage the behaviour-based safety among the workers. Previous studies implied that the organization's safety performances will be improving as long as there is a full commitment by the management to conduct safety training programs (Mukherjee et al., 2000; Varonen and Mattila, 2000). This factor is necessary to the top management to provide proper safety trainings from a competent person to mould their safety attitudes (Mullen, 2004).

A clear safety standard and well-established communication channel within the organization may result in lower numbers of workplace accident. This finding is supported by Kinn et al. (2000), whom found that the effective safety standards and goals awareness in term of safety orientation and communication lead to a lower rate of injury. Moreover, this finding is consistent with other studies and suggested that employees who have received appropriate safety workplace through goal's setting and communication are expected to enhance their safety behaviour (Varonen and Mattila, 2000). It is believed that the workplace safety will works if there is an openness of communication and strong trust among the members (Carroll, 1998; Parker et al., 2001; Yeong and Shah, 2016).

Basically, the safety behavior among firemen is influenced by how they perceive their organization deals with safety issues. If the top management committed to place value through safety policy, procedures and good reward system, the firemen will put safety as their priority. In addition, employee perceptions regarding management's commitment through safety management system and risk control activities may conclude that the safety management as the main criteria in safety climate measurement (Flin et al., 2000). The fundamental for excellent safety performance is generally recognized to a robust safety management system in the department (Smith et al., 1998). Previous study has suggested that the integration of safety management with safety behavior could oversee any human error. It signified the role of management practices as an important factor to compliance of safety behaviour (Tavares, 2009).

Firemen who attended the workplace safety training is aware with various types of hazards and gain skills in controlling the harms. It is essential as the firemen should be better prepared to prevent any injuries or fatality during job duties. It helps firemen to be aware of standard operating procedures implemented in fire department to eliminate existing hazards and dangerous occurrences (Osman et al., 2012).

Thus, it is important to have a positive correlation between safety climate and safety behavior among them. This finding further supports that having proper safety training, good safety management, strong teamwork and good communications will result with more knowledgeable, skillful and have better understanding of job risks among firemen (Taber et al., 2008).

4.0 CONCLUSION

In conclusion, it is found that there was a correlation of the safety climate factors examined in this research towards safety behaviour among firemen. The findings have derived the importance of the organization to assess their workplace safety climate and safety behaviour within this population. As the firemen are exposed to various types of stressors that may risk their life and expose them to physical dangers that possibly lead to traumatic injuries and mental stress, the findings of this study are important for the Fire Department to establish a good and effective organizational safety climate in the organization. The role of these perceptions is vital to highlight if any organizational system and physical changes are required. It is recommended that all organizations regularly monitor their workplace safety climate to improve the safety behaviour of the employees.

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Short Article

Electronic Workstation Ergonomics Self-Assessment Tool

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ABSTRACT: *Work-related musculoskeletal disorders are an important cause of work-related ill health. One of the causes is poor workstation ergonomics. Digitalization enables more efficient and effective ways to enhance ergonomics at the workplace. In this paper we share an electronic self-assessment tool for workstation ergonomics which we developed for our organization. This electronic tool can either be used online i.e. connected to company intranet or as a mobile application (app). The questions focused on ensuring a safe setup and promoting neutral body postures during the use of computer equipment and accessories. Strengths of this tool are: it was developed and can be maintained by in-house resource; it uses software already available in-house; there were no additional costs to the organization; data is secure and can be kept indefinitely on the company server; the tool is interactive and user-friendly; it can be used to assess workstation at home.*

Keywords: *Ergonomics, Self-assessment, Workstation*

1.0 INTRODUCTION

Employers are required to ensure that the safety, health and welfare of all their employees (Occupational Safety and Health Act, 1994). There has been an increasing trend of occupational disease due to ergonomics risk factors in Malaysia and this led to the publication of Guidelines on Ergonomics Risk Assessment at the Workplace (Department of Occupational Safety and Health, Ministry of Human Resources Malaysia 2017). These guidelines promote the use of self-assessment in ergonomics risk assessment in the workplace. Industry 4.0 which promotes digitalization is well known worldwide. Malaysia has a National Policy on Industry 4.0 (Ministry of International Trade and Industry, 2018). For BASF, digitalization is an integral part of our business and an important measure to enhance our efficiency (BASF, 2019a). Hence, to enhance ergonomics at the workplace in an efficient manner we developed an electronic workstation ergonomics assessment tool. This paper will share more information about this tool.

2.0 CONTENTS

The BASF Asia Pacific office ergonomics program (BASF, 2019b) contains both training and assessment modules. The assessment module includes an assessment questionnaire on workstation ergonomics arrangement. To increase the efficiency of screening we developed an electronic tool that would enable workstation ergonomics assessment both real-time and online i.e. immediate assessment when connected to company intranet or as a mobile application (app). The questions in workstation self-assessment were to check whether workstation is set up to achieve good

ergonomics, i.e. safe setup and promote maintaining neutral body postures during the use of computer equipment and accessories as illustrated in the table (Fig. 1). The starting page explains the objective of self-assessment screening and how it works (Fig. 2). If the employee's response reveals wrong practice, advice on the required corrective actions is provided (Fig. 3). If the person being self-assessed requires further assessment, they will be directed to the ergonomics focal person at their site (Fig. 4).

Figure 1 Good Ergonomics Practice

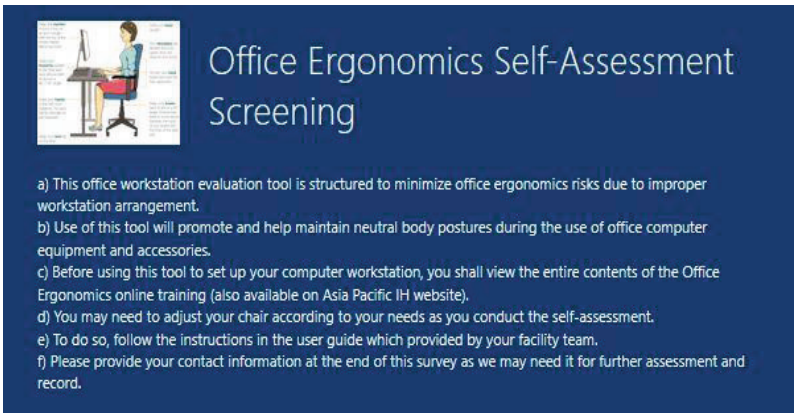

Figure 2 Starting Page of Online Office Ergonomics Self-Assessment Tool

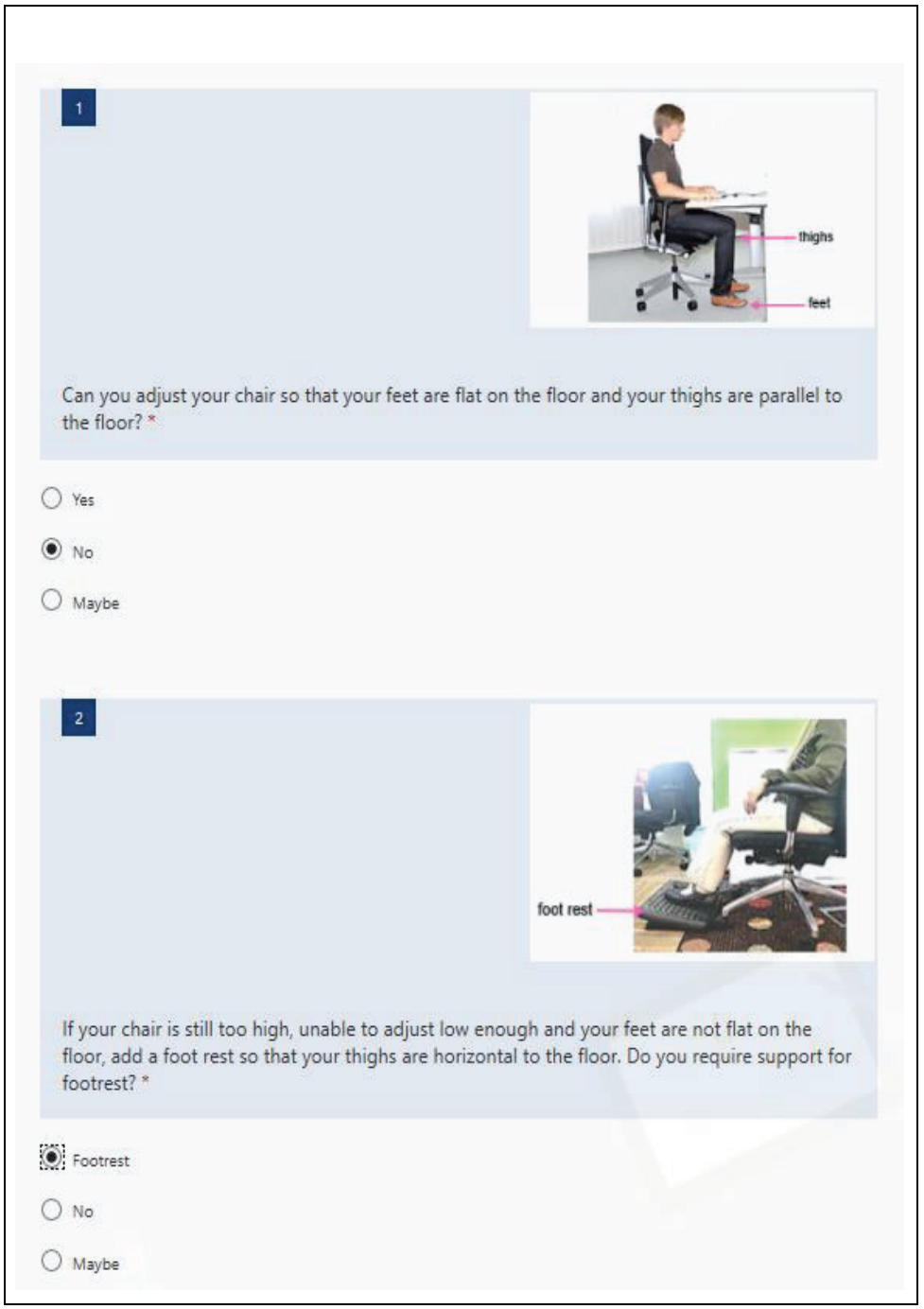

Figure 3 Example of Instruction of Corrective Action Required

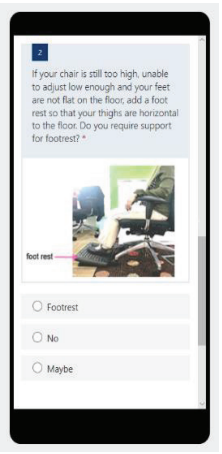

Figure 4 Application on Mobile Phone

This tool has many strengths which are summarised in Table 1.

Table 1 Characteristics of BASF Asia Pacific Electronics Workstation Assessment Tool

Aspects	Comments
Who developed	In-house resource
Who maintains	In-house resource
Cost for tool development	No additional cost
Cost for tool maintenance	No additional cost
Software	Existing company purchased software
Data security	Stored in company servers
Data longevity	Company server
User friendliness	Easy to use. Figures
Interactive	Next question or remark based on response
Home workstation	Can also be used

3.0 CONCLUSION

The BASF Electronic Workstation Ergonomics Self-Assessment Tool provides an example of how existing resources in an organization can be used to develop tools that further improve efficiency of delivering EHS services to employees across offices and sites. This simple digital tool was developed in-house by the relevant subject matter expert i.e. industrial hygienist using existing software available in the organization. The same expert will maintain the tool. Hence the organization does not have to bear additional cost of developing or maintaining this tool. Data security systems and own company server were used to ensure data is safe and accessible. The tool was developed to be user friendly and including appropriate figures. It was interactive whereby next question or remark was based on earlier response, improves user experience. The tool was designed based on principles of good workstation ergonomics and

can be used not only for workstations at the office but also workstations at home. We have found developing this electronic tool a positive experience and believe the product to be cost-effective. We encourage other occupational safety and health experts to develop similar tools to meet their specific needs and share their experience.

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Case Study

Chemical Pneumonitis Following Exposure to Organophosphate Pesticide in Insecticide Spraying Job Task

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ABSTRACT: *The clinical spectrum of respiratory illness in organophosphate poisoning varies from being asymptomatic to chemical pneumonitis and its complications. Large data on clinical features, imaging findings, appropriate management and outcome of this condition is lacking. Chemical pneumonitis is a well-known complication which occurs after inhalation of toxic fumes or gases. Therefore, workers exposed to risk of inhalation to organophosphate pesticides should undergo medical surveillance as required by Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations, 2000. This article highlights the grey areas that need to be improved from occupational safety and health perspective. Failure to go through Fitness to Work (FTW) assessment will breach the safety at workplace that can possibly end up in fatalities. Hence, we urge Pest Control Officer to be aware of the health effect of pesticide exposure and employers need to provide necessary framework of monitoring.*

Keywords: *Chemical, Exposure, Inhalation, Organophosphate, Pneumonitis*

1.0 INTRODUCTION

Pesticides are ubiquitous in the environment and most are synthetic in origin. Due to their availability, pesticides present a continuing health hazard as they are used in agriculture, public health eradication programmes and even as chemical warfare agents. Every year World Health Organization estimated that there are 3 million cases of pesticide poisoning resulting in more than 250,000 deaths. From that number, one million were serious unintentional poisonings and the additional two million people were hospitalized for suicide attempts (Kamanyire & Karalliedde, 2004). In Malaysia, the National Poison Centre reported that 16.4 percent of all admissions to government health facilities from the year 1999 to 2001 were due to accidental exposure caused by pesticides (Ministry of Health, 2004).

Organophosphorus compounds type of pesticides are usually esters, amides or thiol derivatives of phosphoric acid. They form a large family of more than 50,000 chemical agents with biological properties that have important and sometimes unique implications for man (Manoranjan, 2017). Organophosphate insecticides compounds inhibit both acetylcholinesterase and pseudocholinesterase activities (Čolović, Krstić, Lazarević-Pašti, Bondžić, & Vasić, 2013). Acetylcholine is hydrolysed by the enzyme acetyl cholinesterase (AChE) to choline and acetate. Choline is actively taken up by the axonal membrane by a sodium dependant mechanism. Organophosphates inhibit the AChE found in synaptic junction and red blood cells, and butyl cholinesterase (also known as pseudocholinesterase or plasma cholinesterase) in the blood. Blockade of AChE leads to the

accumulation of excessive acetylcholine at muscarinic receptors (cholinergic effector cells), at nicotinic receptors (skeletal neuromuscular junctions and autonomic ganglia), and in the central nervous system (Robb & Baker, 2019).

The clinical spectrum of respiratory illness varies from being asymptomatic to chemical pneumonitis and its complications. Large data on clinical features, imaging findings, appropriate management and outcome of this condition is lacking. No treatment-based randomized control trials have been performed as the number of cases is small. Data on precise incidence of chemical pneumonitis from Malaysia is also lacking mirroring the lack of global data. This article reviews and elaborates a case linked to occupational exposure to organophosphate pesticide in insecticide spraying job task. It also highlights the grey areas that need to be improved from occupational safety and health perspective. The literature on this clinical condition is also reviewed.

2.0 MATERIALS AND METHODS

This is a retrospective review of occupational organophosphate poisoning which relate to pesticide working process involving exposure to organophosphate and compliance failure to Personal Protective Equipment (PPE) usage in a Vector-Borne Disease Control Programme. The review involves secondary data analysis and utilizing data extracted from medical record from hospital and duty records from the District Health Office, in the state of Johor. Accordingly, as the State Health Officers in charge of Occupational and Environmental Health Unit are involved in this study, investigators have the authority and permission to converge and generate data belonging to the case. Subsequently, mixed method approach combining key information interviews, document analysis, secondary data analyses and interpretation conducted by an occupational health expert committee was utilised.

3.0 CASE PRESENTATION

A 28-year-old male worker was brought to the Hospital Emergency Department with complaints of a few hours of difficulty in breathing and chest discomfort. He was having non-productive cough which was progressively worsening over four days' period. He had similar symptoms of cough and flu for past 5 months and visited multiple clinics. However, there was no workplace history taken to relate his symptoms with working activity and his symptoms resolved after taking medicine. Tuberculosis screening revealed negative result.

Upon physical examination, he was tachypneic with respiratory rate of 60 per minute. He's only able to talk in short sentences. His Body Mass Index was 21.8 kg/m^2. His blood pressure was 105/58 mmHg with pulse rate of 116 beats per minute. Pulse volume was good. He was afebrile and lung auscultation revealed reduced air entry at the left lower zone.

4.0 OCCUPATIONAL HISTORY

This worker's placement was at a vector-borne disease control unit in a District Health Office for the past nine months. A Vector-Borne Disease Control Unit is responsible in preventing further spread of vector-borne diseases to human as part of public health control measure. This was his first working experience with the unit and he had no previous history of exposure to pesticide. Job rotation for him was performed in order to give him and other workers opportunity to gain various experience and knowledge in public health disease control and prevention measure.

His job comprised of a typical vector control programme activities such as performing insecticide spraying, insect breeding site search-and-destroy and also performing spray-larvaciding (Fig. 1). Additionally, he was also involved in preparing pesticide mixture to be used in spraying (Fig. 2). According to Malaysian Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations, 2000 (Department of Occupational Safety and Health - USECHH Regulations, 2000), workers exposed to

organophosphate insecticide should undergo periodic medical surveillance which include Blood Cholinesterase Test, Audiometry and Spirometry.

He was supplied with PPE namely half face respirator with cartridges, goggles and coverall to be worn at the field. His other tasks during insecticide spraying or fogging was to guide and assist the fogger in safe direction and give instruction if there is any potential hazard in front that can't be seen in. In this role, although he was not operating the fogging machine directly, he would accompany his designated worker/fogger within 10m radius and hence exposed to pesticide about 2-3 hours each time of the activity. In addition, he was assigned for fogging activity every alternate day for about 2-3 hours each time. He is new in the Unit and he diligently obeyed any tasks given to him in order to avoid any conflict with his supervisor.

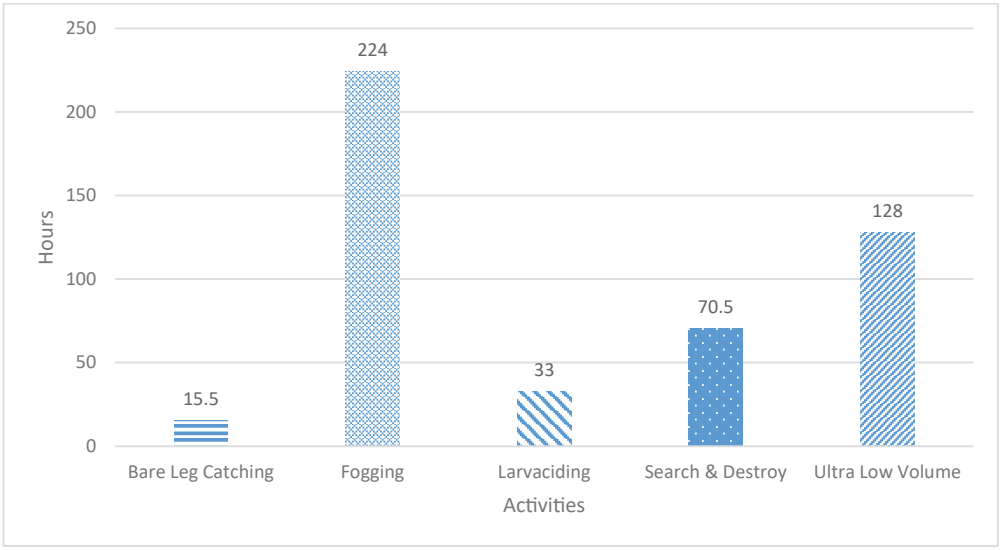

Figure 1 Job Task Analysis of a Public Health Assisstant Over Four Months Period

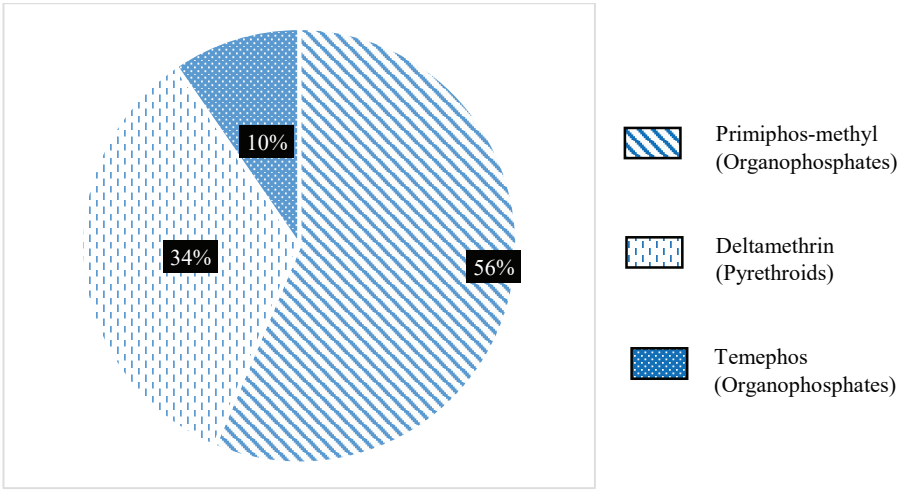

Figure 2 Percentage of Chemical Used Daily by a Public Health Assistant during Work Period of Four Months

5.0 SOCIAL HISTORY

He is single and he stays with friends at a rented house. His family is staying in a different state and he visits them during holidays and weekend.

6.0 RESULTS

On admission his blood pressure was 105/58 mmHg and he was tachycardic (116 beats per minute). Oxygen saturation was 95 per cent under High Flow Mask of 15 litres per minute. Auscultation of the lung revealed reduced air entry at the left lower zone. Chest X-ray showed alveolar infiltration at the left lower lobe and consolidation at right lower lobe (Fig. 3). Arterial blood gases showed Respiratory Failure Type 1 and he was intubated for seven days.

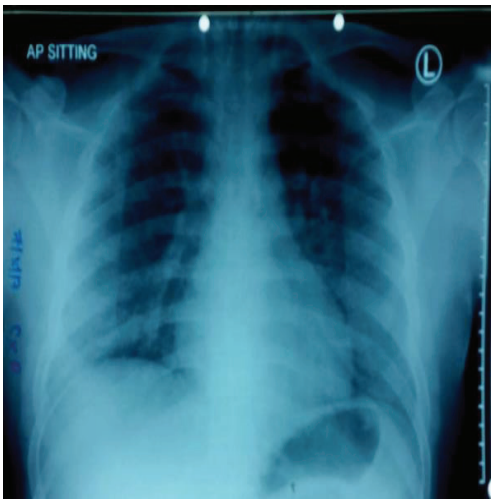

Figure 3 Chest X-Ray on Day 1 of Admission Showing Alveolar Infiltration at The Left Lower Lobe and Consolidation at Right Lower Lobe

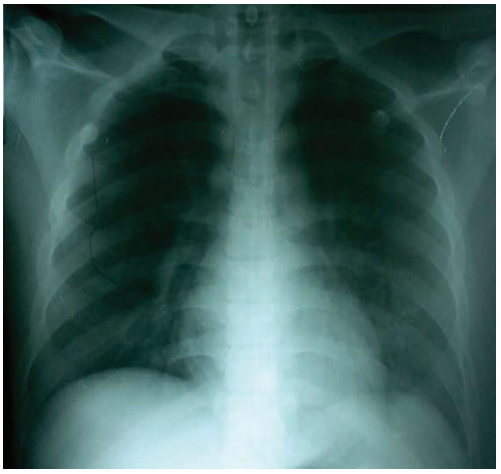

Figure 4 Chest X-Ray on Day 11 of Admission Showing Improvement after Treatment

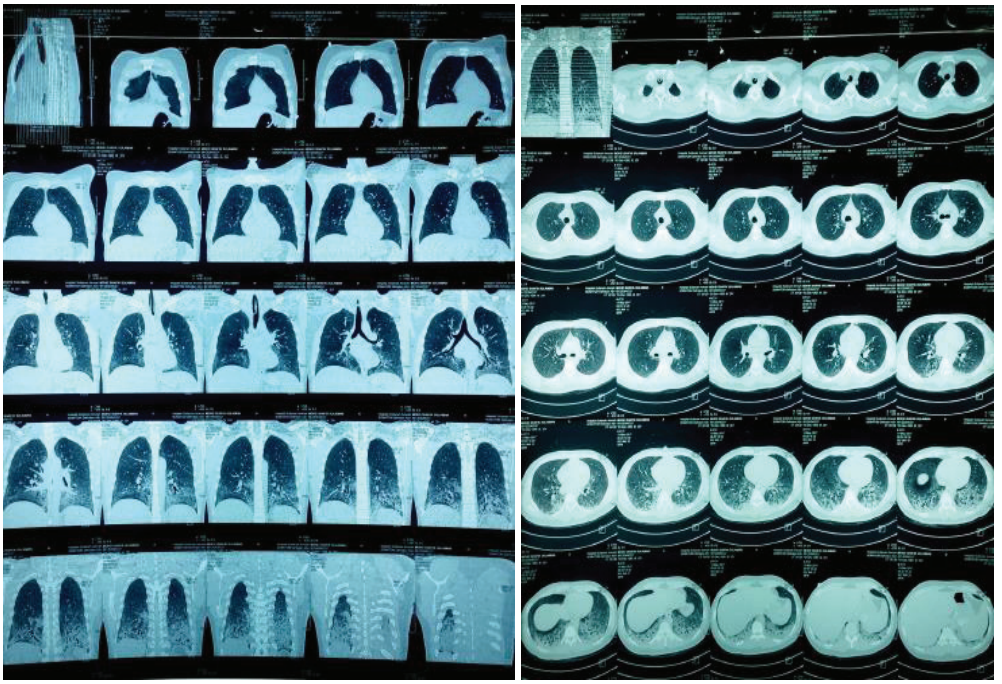

Figure 5 Lung High Resolution CT (LHRCT) on Day 7 of Admission Showing Generalised Ground Glass Pattern in a Mosaic Distribution Bilaterally, with Crazy Paving Pattern and Bronchiectatic Changes in The Lower Lobe Bilaterally

Lung High Resolution Computerised Tomography (LHRCT) (Fig. 5) showed generalised ground glass pattern in a mosaic distribution bilaterally, with crazy paving pattern and bronchiectatic changes in the lower lobe bilaterally. There were multiple ill-defined nodular consolidations scattered in both lungs, mostly in the peripheral compartment, largest was in the lingular segment of the left upper lobe, 0.4 cm in size. Consequent chest x-ray showed progressive improvement by Day 11 after treatment (Fig. 4). He was discharged after 11 days of stay in hospital. Repeated LHRCT after four months showed complete resolution (Fig. 6).

Figure 6 LHRCT Showed Complete Resolution after Four Months

Spirometry showed restrictive changes which gradually improved over time (Table 1, Fig. 7-8). Lung gas transfer as measured for diffusion capacity to carbon monoxide (DLCo) was also reduced indicating presence of parenchymal lung disease. In this case highly suggestive due to inhalation of organophosphate.

Table 1 Spirometry Results During Follow-Up Visits

Date/LFT	Predicted Value	Measured	Predicted Value	Measured	Predicted Value	Measured
Day	Day 11		Day 29		Day 72	
FEV1	3.23	1.79	3.23	2.15	3.23	2.33
FVC	3.77	2.03	3.77	2.31	3.77	2.58
FEV1/FVC	86%	88%	86%	93%	86%	90%
DLCo (mL/mmHg/min)	Not done		25.60	8.90	Not done	
PEF (L/min)	633	235	633	358	633	421

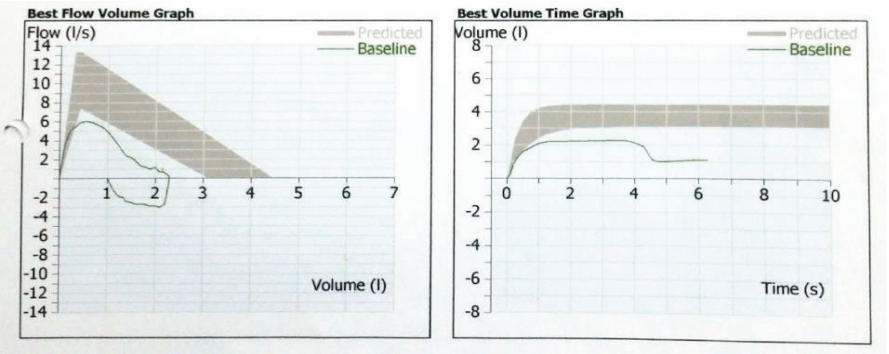

Figure 7 Flow Volume Graph & Volume Time Graph at The Day 29 Of First Month

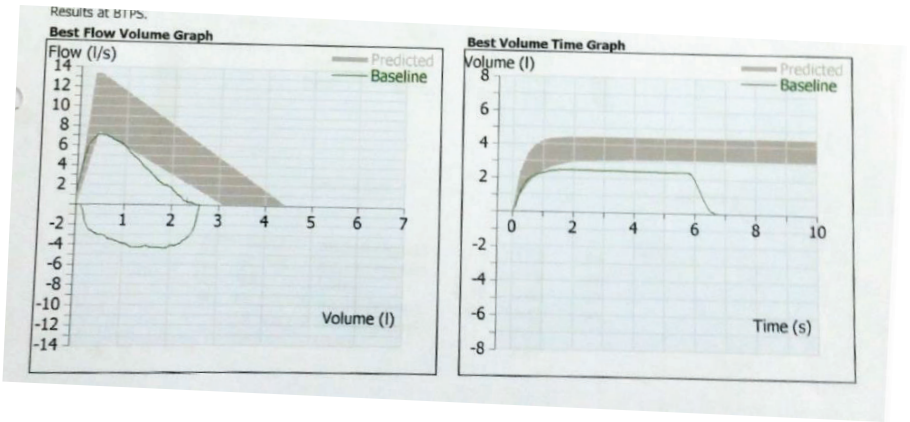

Figure 8 Flow Volume Graph & Volume Time Graph at The Day 72 of Second Month

During interview, it was noted that there was a lack of knowledge and awareness among the worker's supervisors about health impact due to exposure to organophosphate. Fitness for work assessment was not planned well to be conducted prior to the job task. Due to constraint of manpower and packed timetable, his baseline blood cholinesterase test was not done, establishing no data to be compared. There was also no evidence of any respiratory fit testing or training given on effective and efficient usage of PPE. Our interview with his buddy and performance of walk through survey at his work station found poor occupational safety compliance and he was likely to be exposed to pesticide during fogging activities.

7.0 DISCUSSION

The pesticide groups he was exposed to are organophospates and pyrethroids. Primiphos-methyl and temephos are organophosphate pesticides that inactivate AChE, so the irreversible blockage of this enzyme, which causes acetylcholine accumulation, results in muscle overstimulation (Fig. 9). Meanwhile deltamethrin, a member of pryrethroid pesticides, acts on cellular sodium channel (Fig. 10) and causes nervous system dysfunction such as facial paraesthesia, which can be described as feeling many different abnormal sensations, including burning, partial numbness, "pins and needles" and skin crawling.

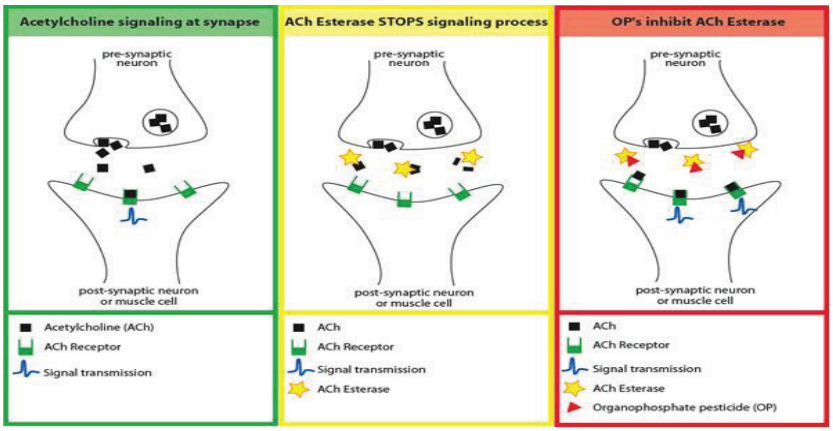

Figure 9 Mechanism of Action of Organophosphate Poisoning (University of Washington, 2007)

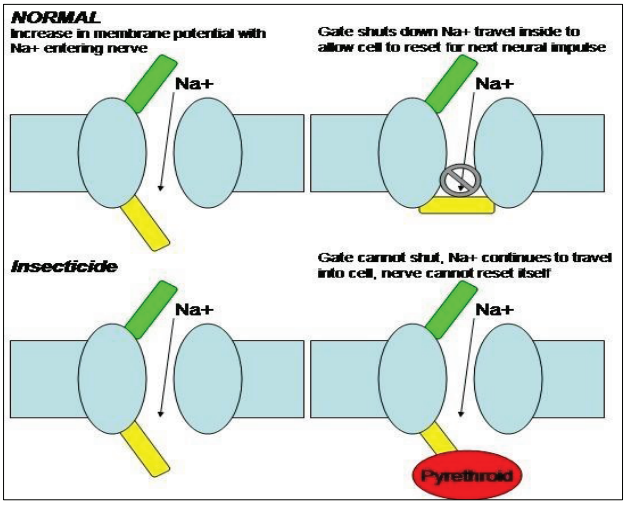

Figure 10 Mechanism of Action of Pyrethroids Poisoning (Manorajan, 2017)

The concentration of organophosphates contained in the form of primiphos-methyl and temephos used by the worker were 49% ww and 44.6% ww respectively. Meanwhile, the concentration of deltamethrin used was 25% ww (Malaysia Ministry of Health, 2005). All three pesticides used during past 3 months prior to the illness were registered with the Pesticide Board Malaysia to be used in public health activities. In this case, primiphos-methyl is used for mosquito adulticide in the form of thermal fogging while temephos was used in the form of liquid spray in residual mosquito adulticide function. Deltamethrin was used for larvicidal activities. The authors were in the opinion that the worker was mostly exposed to primiphos-methyl since primiphos-methyl was the most commonly used pesticide (Fig. 2) and thermal fogging produced a much smaller droplet size that can be easily inhaled and absorbed via respiration (World Health Organization, 2003).

Organophosphates can be absorbed through the skin, respiratory system and the gastrointestinal tract. In this case, the route of exposure is more likely via inhalation thus giving a direct effect to the respiratory system. Bronchospasm and bronchorrhea can occur due to the muscarinic effects of organophosphates and involvement of respiratory muscles may lead to respiratory depression (Elspeth J. Hulse, James O. J. Davies, A. John Simpson, Alfred M. Sciuto, and Michael Eddleston, 2014). Meanwhile, deltamethrin is used in liquid form, mixed with water and sprayed to stagnant water surfaces as a larvacide in this case. In view of improper use of PPE by the worker, exposure to deltametrin was most likely via inhalation and skin absorption. Toxicity-wise, deltamethrin is considered low in toxicity by inhalation when compared to organophosphates with a 4-hour LC_{50} of 2.2 mg/L and a 1-hour LC_{50} of greater than 4.6 mg/L in rats (Gowrinath, Shanthi, Sujatha, & Murali Mohan, 2012).

It is difficult to assess dose-response effect of the pesticide to the worker as exposure assessment was not done. It is partly due to the mobility of the worker while at work and the open space involved. Another aspect to be considered is the proper hazard control is not adequate and it is indirectly due to poor adherence to safe working procedure. The employer has published two relevant documents that can help in establishing safe working procedure in the form of a guideline for storage and handling of insecticides (Ministry of Health, 2004) and another for prevention of workplace accident (Ministry of Health, 2009*)*. The former has information on step by steps of "do and don't" in handling insecticide while the latter explained the how to prevent occupational accidents and diseases by framing the responsibilities of employer and employees in accordance to Malaysian occupational safety and health legal framework. However, with regard to chemical hazard that is relevant in this case (pesticide), the latter document only touches on superficial principles of hazard control.

As stated in Occupational Safety and Health Act 1994 Part IV Section 15 (2) (b), employer is responsible in ensuring, so far as is practicable, safety and absence of risks to health in connection with the use or operation, handling, storage and transport of plant and substances. Hence, Ministry of Health had drafted a Cholinesterase Screening Program for Foggers in 2016. Plasma cholinesterase screening test was highlighted in the Use and Standard of Exposure of Chemicals Hazardous to Health Regulations, 2000 (USECHH) (Department of Occupational Safety and Health, 2000) whilst Red Blood Cell Cholinesterase level was recommended for diagnostic purpose. The tests were carried out by designated laboratory officers at Public Health Laboratory. The officers are trained to conduct the tests. The procedure manual is available at the laboratory for reference. This are case, the test was run using Olympus-D/P/01-002 analyzer which was calibrated daily by the officer and maintenance performed by the appointed third party once every six months.

The most challenging part is to ensure foggers are rested for one month duration from the last exposure to organophosphate to establish a baseline serum cholinesterase as there is manpower shortage to carry out vector control activities during that period. Fogging activities, need to be performed as soon as vector-borne infectious disease cases were reported and in this case, there was a surge of cases. Two samples of worker's blood were taken to get an average value of baseline serum cholinesterase and it will be periodically compared with post exposure values. The first sample was taken after the rest meanwhile second sample was taken between day four and day fourteen of the first sample (Fig. 11). Due to the effect of ageing on cholinesterase level, baseline serum cholinesterase need to be reviewed once every two years (Roberts, 2007.).

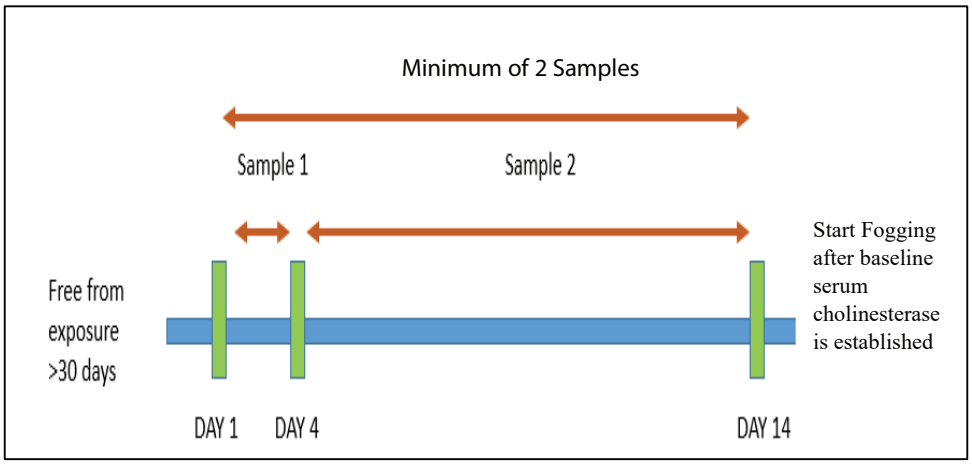

Figure 11 Timeline to Establish Baseline Serum Cholinesterase Level

The challenges in establishing baseline cholinesterase level in this setting could arise due to the following factors:

1) Coordination among workers (on annual leave, day off, medical leave, etc).
2) Workers need to rest for one month in order to establish baseline serum cholinesterase level, thus depriving available manpower for pesticide spraying activities.
3) Serum cholinesterase can only be done at one laboratory in the city of Johor Bahru, the state capital of Johor. Therefore, supervisor need to pre-plan between workers and despatch team to send the sample in timely manner to the laboratory. Time constraint is an issue for districts far away from Johor Bahru.
4) Reassessment of baseline serum cholinesterase once every two years. The existing workers might have been transferred to other unit and there is a need to establish new baseline for new workers.
5) Lack of awareness among supervisors and workers on the importance of serum cholinesterase as the indicator of organophosphate poisoning.

We noticed there were grey areas in conducting medical surveillance and we would recommend the following measures for the workers in Vector Borne Disease Control unit:

1) Improve and strengthen awareness among the supervisors that it is compulsory for them to send their workers for fitness to work assessment at the Occupational Health Clinic.
2) Develop script related to Occupational Safety and Health for supervisors to inform and brief their workers at each roll call session.
3) Improve collaboration between supervisors and Occupational Health Unit to conduct courses to ensure effective and efficient use of Personal Protective Equipment (PPE) by the workers.
4) Establish integrated discussion with higher management to strengthen safety and health at workplace which include periodic monitoring and auditing.
5) Develop a logbook with specific training pertaining to the hazards encountered during working process.
6) Gazette the Ministry of Health document for Cholinesterase Screening Program for foggers to make it a legally binding document to be followed as a guide and reference for the supervisors and medical officers to conduct medical surveillance.

8.0 CONCLUSION

Chemical pneumonitis is a well-known complication following inhalation of toxic fumes, toxic gases or pesticides. The spectrum varies from asymptomatic focal inflammatory reaction to life threatening condition. Workers exposed to organophosphate pesticides should undergo medical surveillance which includes spirometry and cholinesterase blood screening as required by the Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations, 2000. Failure to go through Fitness to Work (FTW) assessment will breach the safety at workplace that can possibly end up in fatality. Hence, we urge Pest Control Officers to be aware of the health effect of pesticide exposure and employers need to provide necessary framework of monitoring.

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