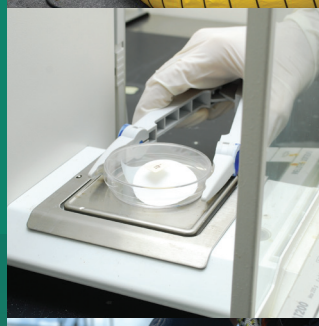
December 2016, Vol 13, No 2
ISSN 1675-5456
PP13199/12/2012 (032005)

Journal of Occupational Safety and Health



National Institute of Occupational Safety and Health (NIOSH)
Ministry of Human Resources Malaysia

Journal of Occupational Safety and Health

The Journal

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

Journal of Occupational Safety and Health

December 2016 Vol. 13 No. 2

Contents

Introducing the Journal of Occupational Safety and Health

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

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

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

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

Apart from that JOSH aims:

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

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

• To inform OSH practitioners and students of current issues

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

From the Editor in Chief

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

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

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

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

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

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

Hj. Zahrim Bin Osman
Editor-in-chief

Ornamental Potted Plant as Air Bio-filters for Indoor Environments

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Abstract: *The cultivation of indoor plants in indoor environment has become a topic of interest among researchers worldwide for its potential to improve indoor air quality (IAQ). However, the adaptations of environmental factor of each plant need to be investigated to correspond with the native environment. The study investigate the capability of plants selected to live indoor. Before experiment was conducted, all plants selected were assimilated with indoor environment for two months. Photosynthesis proses in this experiment will be a guidance to determine the comparative for every plant. The portable photosynthesis system equipment (LI-COR 6400) was used to determine the level of photosynthesis rate for each of plants. Accordingly, among of all plants tested, Spider Plant showed less effective to be grown with indoor environment by the rate of photosynthesis value up to -0.15. Moreover, light compensation point (LCP) of Spider Plant also indicated the light intensity consumption was 2960 lux which is extremely higher than 300 lux. As a conclusion, only six plants in this study which are Anthurium, Dumb Cane, Golden Pothos, Kadaka Fern, Prayer Plant, and Syngonium are able to survive with indoor environment. In the next stage of study, this six plants may give good results to enhance the IAQ.*

Keywords: *Environment, Indoor Air Quality (IAQ), Indoor Plant, Photosynthesis.*

1.0 Introduction

Bringing plants into accommodation is usually done by former society without known about their advantages (Bringslimark, Hartig, & Patil, 2009), while it capable to treat indoor air. Previous researchers claimed that, certain plants are able to place indoor and have potential to give lots of benefit to the human, especially to purify the air (Deng & Li, 2012; Tarran, Torpy, & Burchett, 2007; Wood *et al*., 2006). Besides that, plants in the building also provides thermal comfort to the occupants and can reduces the energy consumption (Newkirk, 2014).

During 1980's, one report has been documented and published by National Aeronautics and Space Administration (NASA), shows that the particular plants are able to reduces gas pollutions in scientific method (B.C. Wolverton, 1989; Soreanu *et al.*, 2013). Since then, there are other researchers who are interested on this bio-filtration research such as B.C. Wolverton (1993), Nelson *et al*. (2011), Dela Cruz *et al.* (2014), and Zhou *et al.* (2011) that are filter out chemical compound using plants. By doing so, absorption of contaminants by plants is not a fairy tale, because the demonstration has been carried out.

However, capabilities of plant to live indoor become an issue. Plants originally come from outdoor region (Smith, 2007), and definitely there are different ambient compare to the indoor. Plant growth may be disrupted when occurrence of environmental change (Amedie, 2010; Stern, 2007). Therefore, sustainability of plant to survive indoor should be given the priority, because this study was conducted in different climate compared to former researchers.

In Malaysia, equatorial climate temperature and relative humidity at the outdoor in range of 23.8-32.1^{0}C and 77.7-92.4% (Malaysian Meteorological Department, 2013) while indoor temperature and relative humidity at Malaysia that was permitted by Industry Code of Practice On Indoor Air Quality (ICOP, 2010) in range of 23-26^{0}C and 40-70%.

Temperature is one of the factors that influence plant to live (Oquist *et al.*, 1993; Ribeiro *et al.*, 2006; Way, 2013) and directly it will effects plant performance to absorb pollution. Live plants compulsory to do photosynthesis process, because, with this processing, plant is able to generate their own foods that are used in respiration process (William Hopkins, 2006). Unstable temperature will cause plants not effective to do photosynthesis process, and Whiting (2014) claimed that plant is more performed to do photosynthesis at temperature of 22^{0}C.

Other factor that can affect the plant live is lighting (Yeh & Chung, 2009). Light is very important to the plant as much as temperature factor. Light energy is the first important thing that determined by plant before photosynthesis process conducted, because, stomata cell which is contained at the plant leaf will open when it receives light energy, then will capture the carbon dioxide (CO_2) to complete photosynthesis process (David R. Holding, 2013).

Therefore, before using the plant as air bio – filtration in the building, the researcher must concern about plant to live with indoor environment. Some plants might have tolerance with the different environment from their native to maintained survive, with down-regulated their photosynthetic apparatus when they are acclimatized at particular environment (Weston *et al*., 2000; Burchett, 2011; Sun *et al*., 2014). The objective of this research is to determine the vitality of plant in the building through the photosynthesis process after plant assimilated with the indoor environment. With the proper method as proposed by the former researchers, it will make this study credible.

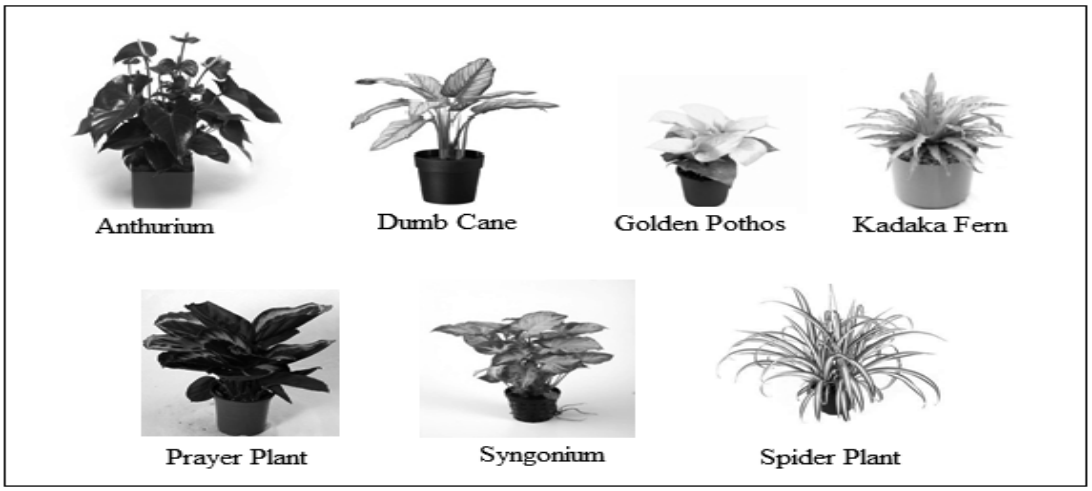

Figure 1: All ornamental plants in this study

2.0 Method

2.1 Plant Material

Figure 1 shows selected ornamental potted plants that was used in this study based on criteria recommended by Wolverton (1996) and Omar-Hor (2006), i.e., originally live under semi – shade, temperature reception is under 27^0C, age of one – year – old, and only healthy plant is involved. Selected plants were indigenious plants found in Johor, grew in 17cm diameter pot and 25cm in height. The pot mixture used consisting of garden soil, compost, and perlite (ratio = 2:2:1).

2.2 Environmental Assimilation

Each selected plant was assimilated in laboratory which climate is follow to office environment for two months prior to the actual experiment. The assimilation process was in accordance to Australian Horticulture (2011). Ambient temperature and lighting were observed as parameters for this study, similarly to studies by Allen & Ort (2001) and Yeh & Chung (2009).

Plants was assimilated with light intensity of 300 lux, in compliance to the minimum lighting intensity for indoor use as suggested by Malaysian Standard 1525 (2007). Relative humidity in the measured room was controlled at <70% RH as permitted by ICOP (2010) and the ambient temperature was set at 25±1°C in accordance to Jabatan Perdana Menteri Malaysia (2014) guideline.

2.3 Photosynthesis Performance

Plant's ability to grow indoor can be ascertained by their photosynthesis level. In this study, a plant's photosynthetic performance after the assimilation process were tested using a leaf-chamber infra-red gas analyzer (IRGA: LI-COR 6400 portable photosynthesis system) with an enclosed leaf area of 6.0 cm^2. Light unit for this equipment is $\mu molPARm^{-2}s^{-1}$ (1 $\mu molPARm^{-2}s^{-1}$ = 74 lux).

Chamber relative humidity was continuously monitored, and ranged from 40% to 60%. From each plant assimilated, young fully opened mature leaves per plant for every species were tested. Relative humidity was controlled based on a suggestion from former researchers (Burchett, 2011).

The illumination provided by LI – COR 6400 to the leaves were gradually increased step-wise at intervals of 0, 2, 5, 10, 20, 50, 100, 200, 350, 500, 1000, 2000 $\mu molPARm^{-2}s^{-1}$. Each intensity level was maintained for 3 to 5 minutes to allow photosynthetic to response to stabilize before increase to the next intensity.

2.4 Data Analysis

Photosynthesis process at plant is proportional with light intensity (Devkota & Jha, 2010). Actually, measurement of photosynthesis level using LI-COR 6400 is based on existence of CO_2 at the leaf-chamber, because, during

photosynthesis, plant also do a respiration for growing purpose (Almusaed, 2011).

Analyses were conducted in accordance to light response curves (LRC) and subsequently leaf-based light compensation points (LCPs) were estimated by interpolation on the LRCs. The LCP is the light intensity at which photosynthesis level at zero, mean that respiration perform at same level (Sterck *et al.*, 2013). Other than that, saturated point from curve graph also considered because by this point, almost all of the plants receive the light after assimilated process is done.

3.0 Results And Discussion

Figure 2 shows LRCs for all seven selected plants. Every species of graph represented by two, where the first graph shows the overall light response on leaf and the second graph show the LCP based on scale that has been shortened. Scale on LCP had to abbreviated because, LCP value on lighting scale is difficult to detect due to numbering scale that are too long (until 2000 µmolPARm^{-2}s^{-1}).

Generally, based on graphs, found that responses curve have a same pattern (even different rate of photosynthesis) with others researchers like a De Souza *et al*. (2005) and Way (2013). Photosynthesis different with other researchers surely due to different plants, but, another factor that photosynthesis rate can varied is environmental, as stated by Drozak & Romanowska (2006).

It can be suggested that higher light intensity resulted in better photosynthesis performance, and photosynthesis rate at 2000 µmol m^{-2} s^{-1} (148000 lux) is 1.53 (Anthurium), 1.41 (Dumb Cane), 1.57 (Golden Pothos), 2.15 (Kadaka Fern), 1.81 (Prayer Plant), 0.03 (Spider Plant) and 0.70 (Syngonium). Plants at the native environment normally have a higher photosynthesis rate compare to plant that are assimilated with indoor environment (300 lux & 25^{0}C±1) during making measurement using LI – COR 6400 (Torpy *et al.*, 2014). The light intensity of 2000 µmol m^{-2} s^{-1} is the maximum light that are provide by LI – COR 6400.

However, for Prayer Plant and Syngonium graph, does not support the assumption, where photosynthesis rate is reduces when reach at 2000 µmol m^{-2} s^{-1}. Plant type for Prayer Plant and Syngonium actually deal with photoinhibition. Photoinhibition is light induced reduction in the photosynthesis capacity of plant, and this is due to light concentration

Lighting Type of plants	**Photosynthesis at 2000 µmol m^{-2} s^{-1} or 148000 lux**	**Photosynthesis rate at 4.05 µmol m^{-2} s^{-1} or 300 lux**	**LCP (lux)**	**Saturation point (lux)**
Anthurium	1.53	0.3	229	74000
Dumb Cane	1.41	0.15	185	74000
Golden Pothos	1.57	0.35	237	81400
Kadaka Fern	2.15	0.1	259	85100
Prayer Plant	1.81	0.15	200	28490
Spider Plant	0.03	-0.15	2960	*undefined
Syngonium	0.70	0.1	296	7178

Table 1: Performance results for all plants using LI-COR 6400

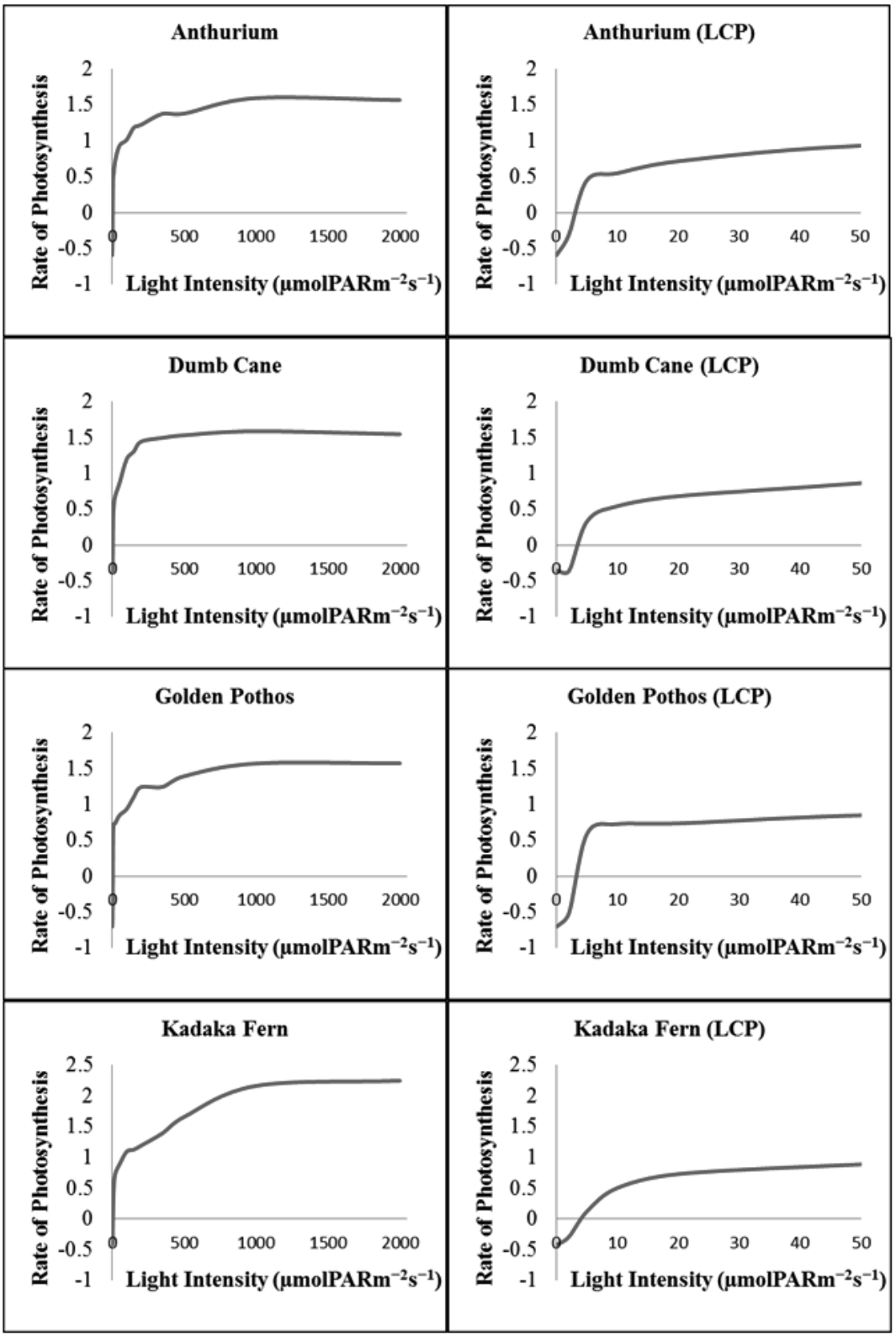

Figure 2: Light responses curve for each of plant

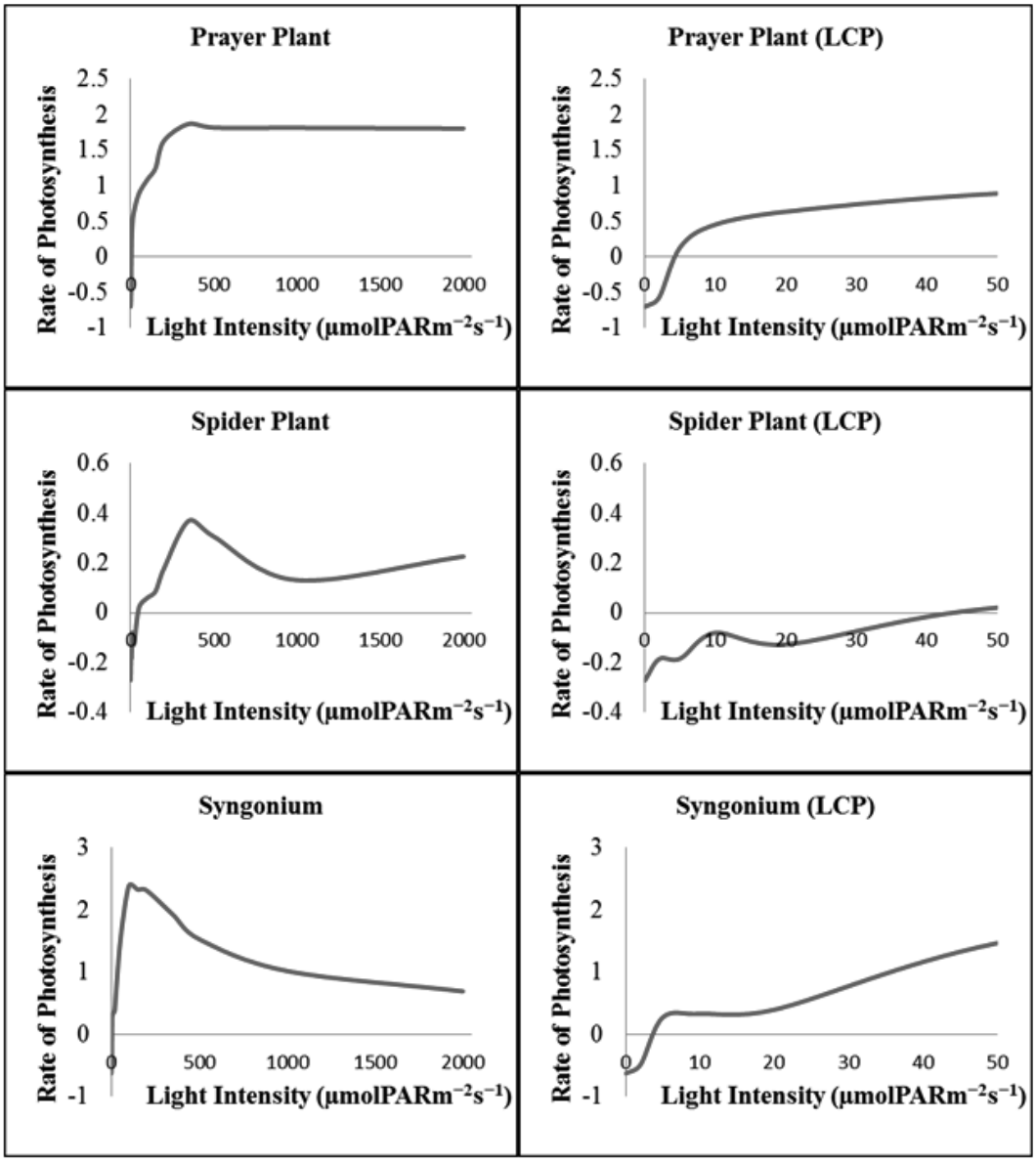

Figure 2: Light responses curve for each of plant (Continue)

is too high (Adir *et al*., 2003).

Meanwhile, Spider Plant also has an issue with the consumption. During assimilation, Spider Plant has problem to adapt with the environment. Spider Plant cannot recover after certain leaf is withering, by germination of new buds such as other plants. In addition, photosynthesis rate for Spider Plant is too small to compare to others, even imposed to high light intensity (2000 µmolPARm^{-2}s^{-1}). It is awkward, after achieve saturated point a 380 µmolPARm^{-2}s^{-1}, photosynthesis rate return to increase at point 1100 µmolPARm^{-2}s^{-1}. Maybe due to unstable plant to assimilate with indoor environment, became the factor and caused thing happened.

Besides that, saturation point (maximum light intensity the plant can accept before plant going to inhibition) for Anthurium and Dumb Cane is 1000 µmolPARm^{-2}s^{-1} (74000 lux), while for Golden Pothos and Kadaka Fern is 1100 µmolPARm^{-2}s^{-1} (81400 lux) and 1150 µmolPARm^{-2}s^{-1} (85100 lux). If Prayer Plant is compare to four plants above, saturation point is quite small (398 µmolPARm^{-2}s^{-1} or 28490 lux), but, Syngonium show the smallest saturation point with value of 105 µmolPARm^{-2}s^{-1} (7178 lux).

After assimilated under lighting and temperature of 300 lux and 25±1^{0}C, researcher want to obtained whether all plants are able to do photosynthesis or not. Photosynthesis is very important for plant live and generated their own food (Eugene & Govindjee, 1969). Normally, when a plant is exposed to the indoor setting, plant must down-regulated their photosynthetic apparatus, for more sensitive with light to perform photosynthesis (Burchett, 2011). So, LCP value will solve this problem. Based on **Table 1**, shows that, all LCP value for each plant is below than 300 lux except Spider Plant, that mean, all plants able to live at indoor condition after assimilated process was conducted. While, at 300 lux, again, only Spider Plant are disable to do photosynthesis with the value is -0.15.

4.0 Conclusion

Overall of this study, it can be conclude that certain plants have abilities to live under different environment from the native. It is based on the results of this study showed the value of LCPs is below than 300 lux, except Spider Plant is 2960 lux. After assimilation by the plant at indoor environment with 300 lux of light intensity is complete, plant should have LCP value below than 300 lux to show the plants were able to survive (make their own food and absorb CO_2). Spider Plant unable to recover itself after miscarriage of leafs. At 300 lux, photosynthesis rate for Spider Plant is -0.15, that mean, respiration was occur more greater than photosynthesis, and of course food production for their own use cannot be made.

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Aspergillus Niger in Tropical Indoor Conditions

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Abstract: *Indoor air quality (IAQ) can be described as the quality of air weather inside or surrounding the buildings and structures which are associated with the health and comfort ability of occupants in the buildings. The level of IAQ in buildings can be influenced by microbial contaminants activities, chemicals exposure and allergens that seriously can create health effects to the building's occupants. In the present study, the effect of environmental factors such as temperature and relative humidity on the optimum growth of Aspergillus niger (A. niger) was investigated. The study revealed that the optimal fungal growth of up 43mm in diameter was evidenced under room temperature of 30°C at the end of a five day incubation period. However, the relative humidity from 40% to 90% applied is able to support the growth of the A.niger. The relative humidity of 90% shows the optimal effect where 56 mm of diameter growth happened after 5 days of incubation. The significant finding to emerge from this study is that environmental factors such as temperature and relative humidity do affect the growth of A.niger. The optimal temperature and relative humidity for A.niger to grow are 30°C and 90%, respectively*

Keywords: *Indoor Air Quality; Aspergillus Niger; environmental conditions; human health*

1.0 Introduction

Nowadays, indoor air quality (IAQ) issue has received awareness from people in the world (Parjo *et al*., 2015; Er, *et al*., 2015; Crook & Burton, 2010). In fact, humans in modern society have been reported to spend 80% or more of their indoors lifestyle, whether at home or at work (Parjo *et al*., 2015). According to Syazwan *et al*.,(2009) and Norhidayah *et al*., (2013) mostly people spend 90% and 80% of their lifetimes in buildings that lead to the comfort and health of the occupants respectively. So, that they were more exposed to the indoor air pollutant. The IAQ in any building can be undermined by microbial contaminants (like fungal and bacteria), chemicals (such as carbon monoxide, formaldehyde), and allergens that can create health effects to the building's occupants (Johansson *et al*., 2005). Numerous researches have shown that indoor microbial exposure in tropical countries with high relative humidity such as Singapore, Thailand and Malaysia can be higher than the average indoor humidity (Parjo *et al*., 2015).

In this study, the *A.niger* was chosen as the organism because this indoor fungal has been related to cause adverse health effects on building occupants. In *A.niger* are organism that naturally presence around us and can be harmful is much exposure to it. Fungi occur because of the problems like building water damage or surface condensations and produce moisture odor (OHS, 2012). All the airborne particles can enter the building through passive ventilation system. The construction materials such as wallpaper and textiles are the source of their nutrients (WHO, 2009). Many fungi and some yeast replicate by producing numerous spores that are well adapted to airborne dispersal. Both spores and fungal fragments may therefore be involved in mould-related adverse health effects (WHO, 2009).

Thus, the high temperatures and humidity in tropical countries climates distribute the impact of thermal discomfort, moisture problems and other indoor air problems (Er *et al*., 2015a, b; Parjo *et al*., 2015a, b). In Malaysia, the Department of Occupational Safety and Health (DOSH, 2010) under the Ministry of Human Resources launched the Industry Code of Practice on IAQ (ICOP-IAQ) stated the parameters distributed to the indoor air contamination. This guideline improved the IAQ that prevents uncomfortable adverse health impact among employees and other occupants. The good IAQ is notably needed for a healthy indoor work environment.

In addition, the temperature is a relative to measure of hot and cold condition in the building. Several studies have revealed that the air temperature and humidity influenced the smell and caused poor indoor air quality (Parjo *et al*., 2015b). The poor indoor air quality dominated by the temperature and humidity compared to other pollutants in the air. In Malaysia, the Industry Code of Practice (ICOP-IAQ), Department Occupational Safety and Health (DOSH, 2010) has been practice to ensure employees and occupants are protected from poor indoor air quality. The acceptable range limit for temperature according to ICOP-IAQ given by DOSH (2010) is between 23°C to 26°C. Normally, irritation symptom on eyes, nose and throat, dry skin, chapped lips occurred on human when the surrounding humidity is too low. Meanwhile, if humidity too high, fungal grow effectively due to the surface condensation and at once produce unhealthy work condition (OHS, 2012). The acceptable range limits of relative humidity according to ICOP-IAQ given by DOSH (2010) are 40% to 70%.

The high amount of total fungal count caused the bad condition and ventilation system. High amounts of humidity contribute to the fungal growth (Luksamijarulkul *et al*., 2012). Daily air movement of heating, ventilation and air conditioning (HVAC) system related to fungal contamination. This HVAC system is switched on in the morning and switched off at the end of the working day can cause fungi breeding in filter and vent ducts (Bonetta *et al*., 2010). As

far we know, the problem has not been considered before especially at the new building.

Besides, many of studies have shown there was a relationship between fungi, humidity and health effect. The high temperature and humidity can cause microbial growth. Most studies were carried in the temperate region such as Japan's climate, with various months of high temperatures and relative humidity is fine suitable to the growth of several kinds of fungi (Nazar *et al*., 2003). Similarly, Shelton *et al*., (2002), found the fungal occurrence the indoor environment was during fall and summer seasons in the United States. In addition, according to (Frankel *et al*., 2014) high relative humidity and temperature are among the factors contributed to the higher occurrence of indoor fungi.

The effects of normal indoor conditions such as temperature and relative humidity are the factor the *A.niger* growth in the solid or liquid surface. The relationship between temperature and relative humidity are important because there are can effect and limit the fundamental processes of growth and development of indoor fungal. In addition, kindly the both indoor parameter provides some information in the growth of *A.niger* or control and useful in laboratory tests, which are the optimum condition of temperature and relative humidity must be known. This *A.niger* has chosen as the organism for this study of effect indoor parameter because it's common occurrence use as test organisms and can give health effect to the human such as itching, infections, allergies, and the toxic effects (Ababutain, 2013). In the present study, the temperature and relative humidity on the optimum growth of *A. niger* were investigated

2.0 Materials And Methods

2.1 Sampling Method

The sampling point of indoor fungal was firstly determined before collecting. Samples of fungal were collected from selected lecturer's room. The procedure for collecting the fungal was based on NIOSH Manual Analytical Method NAM 0800. Anderson single stage impactor was used for studying the total concentration of viable airborne microorganisms including bacteria and fungi. The malt extract agar (MEA) (Bellotti *et al*., 2013)especially in people with asthma; approximately 80% of these patients are allergic to mold. Antimicrobial coatings are formulated to generate surfaces that are easy to clean and may also incorporate active agents, commonly called biocides, which inhibit microbial colonization, subsequent growth and bio-deterioration of the substrates. Some research lines seek to replace traditional organometallic and organochlorines biocides with environmentally acceptable ones. The aim of this research was, primarily, to explore the possible application of different compounds used in food industry like preservatives to be used as antimicrobial additives for antimicrobial coatings. Four biocides were tested against two different ambient molds isolated from an interior painted wall (Chaetomium globosum and. Alternaria alternate has been used as a nutrient media. The fungi sample was incubated at 25°C. The visible colonies can be counted after incubation in several days from day 1 until days 5 by visual inspection resulting in the sample air as colonies forming units per cubic meter of air (CFU/m^3) (Mandal and Brandl, 2011, Er et. al 2015a). Temperature and relative humidity as an indicator of common indoor air quality were monitored at the sampling location using 4 in 1 tester environment tools. The entire sample was placed in plant growth chamber (Model ThermoStsable SWGC-450) for indoor fungal at the variation of temperature during the study.

2.2 Isolation of Fungi

The colonies of indoor fungal were isolated based on their characteristic. Then the species was identified according to the colony morphology. Furthermore, the isolated of microorganisms sent for DNA sequencing to the commercial company for identification species level (Er, *et al*., 2015a). Then the samples were assessed for enumeration of viable indoor fungal in the microbiology laboratory. The temperature was set at 22 to 40°C to incubated agar plate. Observation of growth was done between one to five days after sampling. The concentrations of indoor fungal per cubic meter of air were calculated and identify by the Neubuer chamber (Kamaludin, 2013, APHA, 2012).

2.3 Experiment Design

The effects of relative humidity which ranged from 40% to 90% incubated in plant growth chamber for five days at constant temperature which is 26°C as stated in Table 1. The duration of exposure for each sample to a particular relative humidity setting is 24 hours throughout 1 week. After five days, the linear growth (mm) was determined accordingly. The growth of *A.niger* was observed and measured daily using ASTM D5590-00 scale rating.

Next, the effect of temperature on the growth of *A.niger* inoculated in agar plates was also studied from 22°C to 40°C for five days at fix relative humidity which is 70% (Table 2). Three replicate plates per temperature were placed in the center of sterile petri dishes containing MEA agar medium. Each sample was exposed at 24 hour for everyday

in incubation period. The growth of fungi was assessed daily along several diameters from the point of inoculation according to ASTM D5590-00 scale rating.

Table 1 The effect of relative humidity testing design at temperature 26°C

	Incubation period (Day)				
	1	**2**	**3**	**4**	**5**
Relative humidity (%) *A.niger* growth was exposed at 24 hours	40	40	40	40	40
	50	50	50	50	50
	60	60	60	60	60
	70	70	70	70	70
	80	80	80	80	80
	90	90	90	90	90

Table 2 The effect of temperature testing design at relative humidity 70%

	Incubation period (Day)				
	1	**2**	**3**	**4**	**5**
Temperature (°C) *A.niger* growth was exposed at 24 hours	23	23	23	23	23
	24	24	24	24	24
	25	25	25	25	25
	26	26	26	26	26
	27	27	27	27	27
	28	28	28	28	28
	29	29	29	29	29
	30	30	30	30	30
	31	31	31	31	31
	32	32	32	32	32
	33	33	33	33	33
	34	34	34	34	34
	35	35	35	35	35
	36	36	36	36	36
	37	37	37	37	37
	38	38	38	38	38
	39	39	39	39	39
	40	40	40	40	40

3.0 Results And Discussion

The result of the effect of temperature and relative humidity on the growth of *A.niger* is present in figure 1 (a) and (b), respectively. All the temperature tested mostly supporting the growth of fungus. The temperature 30°C favors colony diameter growth for *A.niger* and considered as an optimum temperature growth at 43 mm of diameter after five days of the incubation period. The growth of *A.niger* starts to increase from 22°C up to the maximum point at 30°C, and start to decrease steadily when subjected to temperature above than 31°C and onwards. Obviously, all relative humidity trials support the growth of the *A.niger* within five days of incubation time. Moreover, at 90% relative humidity was 56 mm of diameter after 5days of incubation period. While the less growth is 30 mm diameter was observed at 40% relative humidity. This result showed that the growth of the *A.niger* increased with the increasing of increased

relative humidity.

Thereby, the temperature was clearly the most important factor in persuading the growth of fungi. Normally the growth temperature for the majority of fungi is between 25°C to 30°C but beyond of 40°C, the growth is decreasing significantly (Ababutain 2013; Shehu & Bello, 2011; Astoreca *et al*., 2007; Palacios *et al*., 2005)times of incubation and temperatures on the growth of A. ochraceus, A. carbonarius and A. niger. Spores of A. ochraceus, A. carbonarius and A. niger were inoculated onto three culture media: Czapeck Yeast extract Agar (CYA. The present finding also in line with studies done by (Ababutain, 2013) which concluded that the colony diameter of *A. niger* was 30°C as the maximum growth. In addition, this finding is consistent with the result obtained by Nawar, (2008) and Nourah, (2008) where they found that the *A.niger* growth optimally at 30°C. However, according to Al-Garni *et al* 2007 found that *A.niger* accepts optimum linear growth at 25°C. But, the above findings contradict with the study done by Palacios-Cabrera *et al*., (2005) in which they obtained that the optimum temperature for *A.niger* growth was 30°C and above.

Thus the present study deals, the tested of *A.niger* failed to grow from 31°C to 40°C. In temperature trials, the result obtained does not support the statement made of (Saleh M. *et al*., 2007) who revealed that *A.niger* grow poorly at 10°C and 55°C. In addition, Nawar, (2008) found that *A.niger* inhibitory to grow at temperature 15°C, which contrasts with the result attained in the present study. The growth of tested *A.niger* was highly influenced by the *A.niger* differential of relative humidity employed. This study revealed that the growth of *A.niger* increased to the maximum growth when subjected to 90% of relative humidity. Meanwhile, the minimum growth of *A.niger* was recorded at 40% of relative humidity. On the other hand, *A.niger* prefers to grow nicely at 75% (Ababutain, 2013). This is in good agreement findings by (Saleh M. *et al*.,2007) and Nawar, (2008) that proved that *A.niger* was able to grow by increase the relative humidity up to 100%

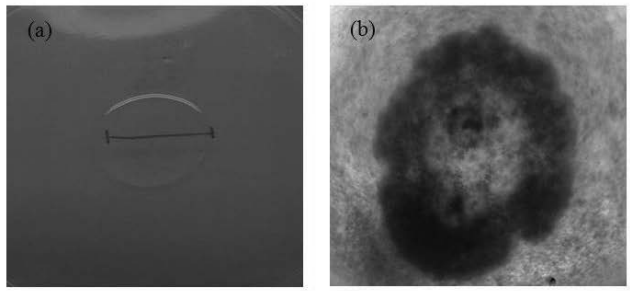

Figure 1: *A.niger* growth on MEA plates (a) initial (b) final condition

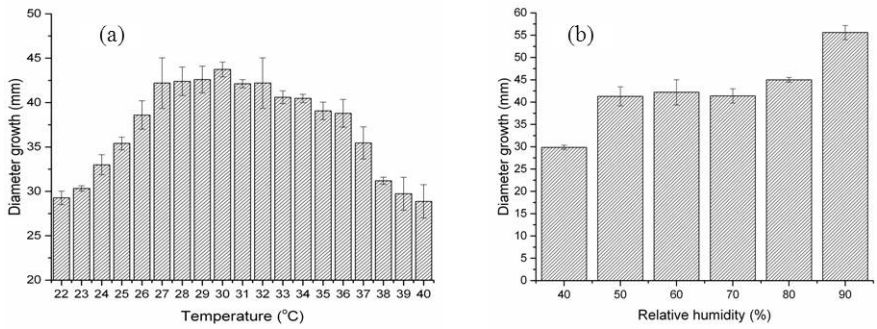

Figure 2: The diameter growth of A.niger based on the effect of (a) temperature and (b) relative humidity

4.0 Conclusion

One of the more significant findings to emerge from this study is that environmental factors such as temperature and relative humidity do affect the growth of *A.niger*. The optimal temperature and relative humidity for *A.niger* to grow are 30°C and 90%, respectively. Therefore, it is highly recommended that indoor room condition should be maintained in acceptable range as suggested by ICOP-DOSH (2010) to prevent the indoor fungal infection, specifically as *A.niger*.

Both temperature and relative humidity obtained in this investigation were not complied with ICOP-DOSH (2010) standard guideline. This standard clearly states that the acceptable limit for temperature and relative humidity has been set at 22-26^{o}C and 90%, respectively. Future works probably by extending the range of temperature and relative humidity studies. Yet, to establish an effective control the activities of this fungi species that renown able to give health effect to the human especially in building.

Acknowledgements

The authors would like to thank Universiti Tun Hussein Onn Malaysia under MyBrain15 FRGS (Vote: 1479) for sponsoring this research. The authors also acknowledged all participants involvement in this research.

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Case Study Of Occupational Hazards Amongst The Gastrointestinal Assistants (GIA) Exposed To Succindialdehyde (SA) In The Endoscopy Unit Of Queen Elizabeth Hospital (QEH)

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Abstract: *Introduction: Workers in hospitals are exposed to various occupational hazards such as high level disinfectants (HLD). Disinfection is an essential component of the endoscope reprocessing. In the Endoscopy Unit of Queen Elizabeth Hospital, Succindialdehyde (SA) is used as the disinfectant for endoscope reprocessing. SA has properties that are similar to formaldehyde in regard to contact allergies and toxicity. The purpose of this case study is to describe the occurrence of work related symptoms (WRS), the proper use of personal protective attire (PPE) and the need of pre-employment health enquiries for those exposed to SA. Methodology: This was a cross sectional case study. Twenty eight gastrointestinal assistants (GIA) from the thirty two exposed staff working with the Queen Elizabeth Hospital's Endoscopy Unit, who fulfilled the study criteria, were given a modified Respiratory Surveillance Questionnaire. This questionnaireis used as the health surveillance tool for the staff exposed to the occupational respiratory hazard by the Occupational Health Unit, University of Edinburgh. Results: Most of the GIAs complained of headache (85.7%), skin irritations (60.7%) followed by 57.1% watery eyes, wheeziness and runny nose. Majority (92.9%) of the GIAs wore personal protective equipment (PPE) during the disinfection procedure. Pre-employment enquiries regarding asthma, skin and mucosal sensitivity problems and lung function were not made to any of the GIAs. Only 14.3% of them do annual health surveillances. Conclusion: Most of the GIAs, 92.9% experienced at least one WRS despite wearing PPE. Staff exposed to the chemical disinfectants should wear proper PPE and do annual health surveillances. By practising this, we may avoid WRS and treat the staff accordingly.*

Keywords: *Succindialdehyde, high level disinfectant, endoscope reprocessing, occupational hazards*

1.0 Introduction

Gastrointestinal (GI) endoscope is a semi-critical medical device used for the diagnosis and treatment of GI diseases. The GI endoscope comes into contact with the mucous membrane of the GI and requires High Level Disinfection (HLD) to prevent transmission of pathogens to the next patient, especially to those who are immunocompromised[1].

The workers in the hospitals are exposed to various occupational respiratory hazards[2], especially the staff engaged in the endoscope reprocessing. They are exposed to the toxic disinfectants, in which symptoms may be made worse by not following the Protective Personal Equipment (PPE) standards and guidelines[3]. Many of the chemical substances are in the form of liquids and gasses and are readily available at hospitals and clinic facilities[4]. These are Glutaraldehyde (GA), Orthophthalaldehyde (OPA), Peracetic acid (PAA), Hydrogen Peroxide (HPO), Electrolyzed Acid Water (EAW), and PAA/HPO blend. All six of these substances have been approved by the United States Food and Drug Administration (FDA)[5]. In other countries, different types of disinfectants have been approved for use. These include Chlorine Dioxide (ClO_2), Peroxygen Compounds, Quaternary Ammonium, and Ozonated Water[5]. In 2002, the use of GA as a disinfectant was discontinued in the United Kingdom, due to its various toxic effects toward the staff[6].

Although the Ministry of Health (MOH) of Malaysia has guidelines to protect the safety of health workers exposed to chemicals, but there aren't any specific standards targeted towards endoscope reprocessing[7]. In the Endoscopy Unit of Queen Elizabeth Hospital, Gigasept FF (Succindialdehyde (SA), OHC-CH CH-CHO, CAS Number 638-37-9) is used as the disinfectant of choice for endoscope reprocessing. It contains 11.0g SA, 3.0g Dimethoxy Tetrahydrofuran and anti-corrosion components. It is a highly reactive compound, and is usually handled as a hydrate or methanol-derived acetal. SA is similar to formaldehyde in toxicity and as a contact allergen. No further toxicological data isavailable[8].

SA is inferior in its microcidal activity in comparison to GA. This is because a higher concentration and a longer contact time are needed to achieve the acceptable endoscope reprocessing results. There are guidelines and strategies to limit adverse outcomes amongst health workers engaged in endoscope reprocessing, however, there are limited data to assess conditions of health workers engaged in reprocessing[3]. Not many studies have mentioned the adverse effect of SA exposure. In a study conducted in the UK[2], 7 out of 30 nurses that had been exposed to Succindialdehyde-Formaldehyde (SF), 56.7% had contact dermatitis, 13.3 % had nasal and eye irritation and others had chronic bronchitis, persistent cough and wheeze.

The purpose of this case study is to describe the occurrence of work related symptoms, use of protective attire and the need of pre-employment health enquiries among the Gastrointestinal Assistant (GIA) of the Endoscopy Unit, Queen Elizabeth Hospital, that have been exposed to SA.

2.0 Methodology

2.1 Study Design

This was a cross sectional casestudy. This casestudy was conducted in the Endoscopy Unit of QEH from October 2015 to November 2015. The participants were checked for eligibility beforehand. The inclusion criteria were, permanent GIA staff working at the Endoscopy Unit, QEH, staff having at least of 6 months of working experience in the endoscopy unit, and who are actively involved in the endoscope reprocessing. The Nursing students and Medical Assistant students attached to the Endoscopy Unit, Queen Elizabeth Hospital was excluded from the study. **They were excluded from the study due to the short exposure time to the disinfectant studied.The respondents were informed about the purpose of the study, which is to determine the effects of the disinfectants on users. Furthermore, the respondents were informed on the methodology of the study.** After consenting, they were told to fill up the given questionnaire.

2.2 Sample Size

This case study was conducted only in one site in Sabah. All the GIAs working in the Endoscopy unit, QEH were invited to partake in the study. **In total, there are 32 GIAs with post basic diploma qualifications. These GIAs consist of staff nurses and medical assistants.**

2.3 Data Collection Tool

The GIA working at the QEH Endoscopy Unit, were given a self-administered modified Respiratory Surveillance Questionnaire adapted from the Occupational Health Unit of the University of Edinburgh[10]. Many researchers have suggested that disinfectants derived from aldehyde groups cause symptoms such as allergic rhinitis, wheeziness, watery eyes and skin irritations[2,3]. Hence, this questionnaire focuses on these symptoms.

The original Respiratory Surveillance Questionnaire has two sections. The first section consists of questions for the workers and the second section is for the Occupational Health Advisor to complete. We have only used the first section of this questionnaire for our case study. Questions were modified according to the hospital practices. The modified questionnaire was then pretested among the GIAs.

This modified questionnaire consisted of 17 questions divided into 5 parts. The first part consisted of demographic data that includes age, gender, qualifications and years of service at the Endoscopy Unit, QEH. In the second part, WRS were obtained from the GIA. This was followed by the history of smoking, previous place of work and pre-existing health conditions in the third part. The fourth part, was on the type of PPE currently being used and if it was viewed to be appropriate by the GIAs themselves. In the final part of the questionnaire, the GIAs were required to inform if they had done any pre-employment assessments and/or yearly health surveillances. They were also asked for their opinion in regards of the importance of doing annual lung function tests and in partaking in health surveillance questionnaires.

2.4 Statistical Analysis

The demographic profile on age and duration working at the Endoscopy Unit is presented in median and Interquartile Range (IQR). All the other variables were binary outcomes, thus proportions were used to describe them. The data was analysed using SPSS version 21. **Only descriptive statistics were used in this case study.**

Ethical clearance

This study was approved by the Medical Research Ethics Committee (MREC), Ministry of Health (NMRR-15-1206-26952).

3.0 Results

Of the 32 GIAs in the Endoscopy Unit of QEH, 28 were eligible and selected to be in the study. The median age for the GIAs was 30 years (IQR=9.5). Majority of the GIAs in the Endoscopy Unit are female staff nurses, 22 (78.6%), the rest are males, with medical assistant backgrounds. The median working duration of the staff at the Endoscopy Unit of QEH is 3 years (IQR=8.1).

On the surveillance of the WRS, 12 of them have developed health conditions or symptoms after starting to work in the Endoscopy Unit. These symptoms are summarized in the **Table I** showed 92.9% of the GIAs experienced at least one WRS. Only two of the GIAs did not have any WRS. 10 (35.7%) of the participants say their symptoms worsen at night. For the majority of them, 26 (92.9%), the symptoms improved during the weekends and holidays.

Table I: Work Related Symptoms (WRS) among the Gastrointestinal Assistants (GIA)

WRS	N (%)
Cough [a]	9(32.14)
Prolonged / repeated sneezing[b]	8(28.57)
Breathlessness	14(50.0)
Wheeziness[b]	1(3.57)
Chest tightness[c]	8(28.57)
Watering eyes[d]	16(57.14)
Running/ Blocked Nose	16(57.14)
Skin Irritation / skin disease[a]	17(60.71)
Headache[a]	24(85.71)

[a] one missing data, [b] three missing data, [c] five missing data, [d] two missing data

Only one worker smokes amongst all the GIAs. 14 of the GIAs have history of working with other hazardous chemicals especially, other HLD such as Gigasept AF (aldehyde free disinfectant). Only two GIAs have been diagnosed with health conditions (vertigo, allergic rhinitis) prior to working in the Endoscopy Unit. Their symptoms have worsened at work.

Majority of the GIAs wear PPE during the endoscope reprocessing (**Table II**). However, 24(85.9%) of them have concerns about the PPE. According to the GIA, the current PPE that is used is unsafe for chemical use. Sterile gloves are not suitable in protecting from corrosive disinfectant, the disposable and N95 Mask does not prevent inhalation of the chemicals and the blue (disposable) gowns and boots are not waterproof, and cannot safeguard against chemical spill injuries.

Table II. Personal Protective Equipment (PPE) worn by the GIAs

PPE	N* (%)
Disposable Mask	19(67.86)
N 95 Mask	25(89.29)
Gown	26(92.86)
Sterile Glove	26(92.86)
Protective Eye Wear	26(92.86)

* N= 27, one respondent did not complete this section

None of the workers underwent a pre-employment enquiry regarding asthma, skin and mucosal sensitivity problems and lung function by spirometry. Four of the workers do annual health surveillance. 26(92.7%) of the workers agree that it is important to do an annual lung function test and to participate in health questionnaires for those involved in endoscope reprocessing.

4.0 Discussion

Many guidelines are available on the steps of endoscopic reprocessing. According to recent guidelines from the Korean Medical Association, seven steps are involved in endoscope reprocessing: pre cleaning, cleaning, rinsing, disinfection, rinsing, drying and storage[11]. Although the estimated rate of transmission of infection via endoscopy is extremely low, at 1 in 1.8 million procedures4, many flaws and deficiencies in endoscope reprocessing can result in microbial transmission. An automated endoscope reprocessor (AER) can be used for HLD. According to the recent update of gastrointestinal endoscope reprocessing, authors say that AER is designed to replace some of the manual reprocessing steps[12]. The use of AER and Endoscope Cleaner and Reprocessor (ECR) is believed to decrease the adverse health outcomes among the workers3. Even though the AER is highly recommended by the World Gastroenterology Organization for the reprocessing of all GI endoscopic instruments, in QEH, all equipment are cleaned manually due to breakdown of the AER and financial limitations (**Figure I, II**).

Figure I. Manual washing of endoscope using HLD

Figure II. GIA staff checking for endoscopy leak

GA is commonly used as a disinfectant in reprocessing of the endoscope[13]. It is an effective disinfectant, relatively inexpensive and non-damaging to the endoscopes, accessories and automated processing equipment, but it has many adverse health outcomes[3]. In our case study, many of the GIAs complain of headache (85.7%), skin irritation (60.7%) followed by watery eyes, wheeziness and runny nose, 57.1% respectively. There aren't any studies that have reported on the work related symptoms amongst those exposed to SA disinfectant. Incidence of occupational asthma, contact dermatitis and keratitis has been reported among staff exposed to GA and PAA. The use of OPA has increased as an alternative to GA for endoscope disinfection. Development of bronchial asthma and contact dermatitis in health care workers employed in an endoscopy unit was detected in the use of OPA[14]. In a systematic review[3], eight studies reported on the adverse health outcomes amongst staff engaged in endoscope reprocessing. More than half of the studies described about respiratory and dermal effect. One study mentioned that health outcomes improved after enforcing the use of the AER. Additional health conditions such as physical discomfort were also identified, and potentially linked to the chemical disinfectants used during reprocessing[3]. A recent study in Korea reported that 74% from the 100 respondents had experienced headache, dizziness, nausea, eye strain, haemorrhage and skin rash after exposure to different types of HLD (GA, OPA, PAA, EAW and hydrogen peroxide)[13].

QEH Endoscopy Unit GIAs have complained of persistent headaches due to the strong smell of the disinfectant and it was made worse by the lack of scavenging systems in the reprocessing room (**Figure III**). WRS of upper airways and eyes depends on the concentration of the disinfectant in the environment (reprocessing room)[2]. According to a study[15], the main reasons for the WRS were nursing staff are not sufficiently familiar with the disinfectants, high concentration of disinfectant in the air, insufficient training to use the facilities and disinfectants and lack of safety precautions due to large amount of disinfectants in examination room. Cleaning and disinfection of endoscopes should be performed in a dedicated room[9,11]. The reprocessing area should be separated from the procedure room and must be well-ventilated to avoid inhalation of vapours[16.]

PPE is defined as specialized clothing to protect the staff against hazards[17]. According to the British Society of Gastroenterology (BSG) Endoscopy Committee, their new guidelines onDecontamination of Equipment for Gastrointestinal Endoscopy, state thatstaff who are involved in endoscopic practice should wear gloves and appropriate protective clothing[18]. In QEH, the staff used disposable masks or N 95 Masks if available, plastic gowns, sterile gloves, and protective eye wear during the endoscope reprocessing (**Figure IV**). Whenever possible, single use accessories will be used. Unfortunately due to limited resources, most of the PPE are used several times before being disposed. Since endoscopic reprocessing-specific attires are not available, and the current PPE does not give adequate protection to the staff,this creates a hazardous working environment for the staff involved.

No pre-employment medical assessment was done on any of the GIAs. According to the BSG guideline, health surveillance of staff is mandatory and should include a pre-employment enquiry regarding asthma, skin and mucosal sensitivity problems and lung function by spirometry[9]. 26 out of 28 of the GIAs agree that it is important to do an annual lung function test and health questionnaire for those involved in endoscope reprocessing.

Figure III. Endoscope Reprocessing Room in the Endoscopy Unit, QEH

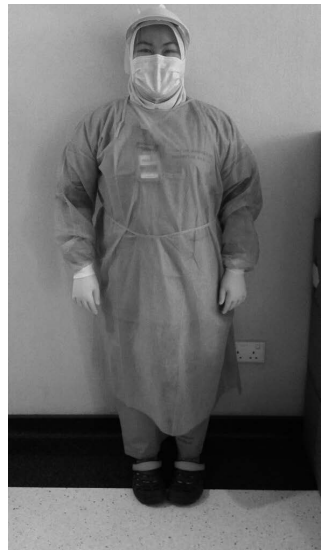

Figure IV. Personal Protective Equipment (PPE) worn by the GIA staff of the QEH Endoscopy Unit

5.0 Conclusion

Most of the GIAs, 92.9% experienced at least one WRS despite wearing PPE. Only 2 out of 28 GIAs did not have any WRS. Although there are many guidelines on the prevention of occupational health hazards, limited resources and budgets have always been a stumbling block. Nevertheless, health care workers exposed to the chemical disinfectant should wear proper PPE and do annual health surveillance. By practising this, we may avoid the WRS and treat the staff accordingly.

Limitations

This case study was only done on one site. We were unable to check the concentrations of the disinfectant in the air to reassure that the symptoms experienced by the GIA were due to SA exposure. More studies need to be done at more centres focusing on the occupational health hazards among those exposed to the different kinds of disinfectants in the Endoscopy Unit.

Conflicts Of Interest

The authors have no conflicts of interest.

Acknowledgement

We would like to thank the Director General of Health Malaysia for his permission to publish this article. Also I would like to thank the staff of Endoscopy Unit, Queen Elizabeth Hospital for participating in this case study.

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Construction Occupational Safety and Health from the Perspective of Malaysian Residential Construction Industry

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Abstract: *Construction industry is one of the major contributors towards Malaysian economy and socio-economy. It is an important industry gearing Malaysia towards developed nation status. However, fatalities in this industry are a crucial problem. Number of fatalities in this industry is the highest compare to other industries registered in Malaysia. The contributing factors can be separated into immediate (human and worksite elements) and underlying (management and external). Occupational safety and health (OSH) management is a challenge in the construction industry due to its hazardous nature. A framework of construction OSH management consisting of policy, process, personnel and incentive elements were tested. 13 respondents from 13 residential projects comprising of high-rise and low-rise in Pulau Pinang were interviewed. It was found that the immediate factors are being more recognized by the respondents compare to the underlying factors. Human element is perceived as the most significant contributor, while the external element is the least significant. In terms of construction OSH management, process and personnel elements are the most significant in developing an effective OSH management programme.*

1.0 Introduction

Construction industry is an important sector that encourages other industries in Malaysia. The impacts of the production in the construction industry are crucial in terms of enhancing the economy of Malaysia as well as the socio-economic through the development of infrastructures (Fadhlin Abdullah, Chai Voon Chiet, Khairul Anuar & Tan Tien Shen, 2004 ; Md Zyadi bin Md Tahir, Azmafailah Jauhari, Norain Mod Asri & Iszan Hana Kaharudin, 2009). The positivity and encouraging scenario of Malaysian construction industry is essential in achieving the status of developed nation.

In the aspect of occupational safety and health (OSH), construction industry is defined as unique, complex and hazardous(Sawacha, Naoum & Fong, 1999; Pinto, Nunes & Ribeiro, 2011; Tam, Zeng & Deng, 2004; Teo, Ling & Chong, 2005; Aneziris, Topali & Papazoglou, 2011). The unique nature of the construction industry in terms of transient workforce, the needs to be working at high elevation, variable hazards and very demanding physical as well as mental requirements for the working process, contributed to accidents in the industry (Abdul Rahim Abdul Hamid, Muhd Zaimi Abd Majid & Bachan Singh, 2008). Im, Kwon, Kim. S, Kim. Y, Ju & Lee (2009) and Pinto, Nunes & Ribeiro (2011) stated that number of fatalities related to construction industry is excessive.

OSH problems in construction are a global issue which are rarely unique to a single country in this global market and more importantly the consistent scenario of injuries and fatalities have transpired this industry as one of the most hazardous workplace (Hinze and Rinker, 2008). The alarming rate of fatalities in the construction sector also was mentioned by Chi & Wu (1997), Sawacha, Naoum & Fong (1999), Behm (2005), Ling, Liu & Woo (2009), Lopez, Ritzel, Fontaneda & Alcantara (2008) and Im, Kwon, Kim. S, Kim. Y, Ju & Lee (2009). Malaysian construction industry that comprises of residential, non-residential, social amenities and infrastructures categories is experiencing a similar OSH issues in the aspect of fatalities.

In resolving OSH issues in construction industry, an effective and well implemented OSH management program is required. A successful OSH management program can be achieved by fulfilling three decisive factors consisting of management leadership, safe workplace and safe work practices (Reese and Eidson, 1999).

1.1 OSH in construction industry

Construction safety management is a challenge due to the nature and characteristics of the industry leading to a disproportionate rate of injuries compared to other industries (Hallowell and Gambatese, 2009).It is important that OSH management in construction industry is being focused from the designing stage and continue throughout the project (Reese and Eidson, 1999). It is also suggested that factors affecting safety performances can be separated to project

level and organisation level (Ng, Kam Pon Cheng & Skitmore, 2005). It shows that OSH management is essential at every stage of a construction project which requires the cooperation of every individual in the industry. Table 1 demonstrated the importance and roles that are required by different sectors in Malaysian construction industry in creating a safer workplace (Mohd Hafiidz Jaafar, 2015).

Table 1: Roles of the sectors in Malaysian construction industry in OSH management

SECTOR	ROLES
Financier	Responsible in affecting the OSH management through economical and financial aspects of the projects
Regulator	The regulator or governmental related agencies have the authority to assure OSH management is being implemented according to legislation.
Supplier	Supplying equipments, machines and construction materials that are safe in accordance to OSH.
Developer/Owner	Possess the capabilities to overlook the overall process of construction.
Consultant	May reduce the risk of occupational accidents and illnesses through design and planning.
Contractor	Contractor has the biggest responsibility in implementing the OSH management program at sites according to legislation and developer requirements.
Labour	As the personnel that directly carrying the construction tasks and exposed to risks of occupational accidents and illnesses, it is important to adhere to OSH management program that is regulated.

1.2 Fatalities in Malaysian construction industry

Malaysian construction industry recorded the highest number of fatalities in the period of 2007 to 2015.Fatalities and injuries in construction industry lead to losses in terms of labour, properties and national development (Mohd Saidin Misnan, Zakaria Mohs Yusof, Abdul Halim Mohammed & Abdul Rahman Dalib, 2013).

Table 2 illustrated the number of fatalities cases that have been investigated by Malaysia Department of Safety and Health (DOSH, 2009, 2010, 2011, 2012, 2014a, 2014b &2016). Within the period of 2007 and 2015, highest number of fatalities recorded in construction industry are 95 (2007) and 88 (2015). In this period of time, percentages of fatalities in construction industries are within 28.98% and 43.38%. This scenario can best be described as critical and need to be managed immediately.

Table 2:Fatalities in Malaysian construction industry

Year	Total of fatalities	Total of fatalities in construction industry	Percentages of fatalities in construction industry (%)
2007	219	95	43.38
2008	239	73	30.54
2009	224	71	31.70
2010	185	66	35.68
2011	176	51	28.98
2012	191	67	35.08
2013	185	69	37.30
2014	204	72	35.29
2015	214	88	41.12

The number of fatalities cases that have been reported and being investigated by DOSH during 2007-2015 is higher than number of cases with permanent disability and without permanent disability. Element of under-reporting could be suggested from this scenario for Malaysian construction industry within this period of time.It was reported that injury rates related to workers compensation claims are higher than the injury rate reported to the authorities (Taylor Moore, Cigularov, Sampson, Rosecrance & Chen, 2013). Accident under reporting can be associated with factors such as age and tenure; fear of reprisals or loss of benefits; general acceptance that injuries are a fact of life in certain lines of work; and production pressure (Probst and Graso, 2013).

Malaysian construction industry depends highly on immigrants. Under-reporting within the immigrants in construction industry are related to insecurities regarding immigration status and job security (Menzel and Gutierrez, 2010). Accident under-reporting provides inaccuracy in number of injuries, illnesses and other OSH indicators that are very crucial in determining the root causes of workplace incidents as well as establishing effective OSH management program (Taylor Moore, Cigularov, Sampson, Rosecrance & Chen, 2013).

1.3 Contributing factors towards OSH accidents and illnesses in construction industry

In this study, the factors contributing to OSH accidents and illnesses have been separated into two main categories which are the immediate factor and the underlying factor. The immediate factor comprises of human and worksite elements. Both of these elements are the obvious contributing factor towards occupational accidents and illnesses. It can easily be identified during OSH accidents and illnesses investigation.

Human element as contributing factor can be associated with unsafe act (Abdelhamid and Everett, 2000). Approximately two third of the accidents that was investigated can be related to human element in terms of behaviour and human capabilities (Haslam *et al*., 2005). Four sub-elements have been established for this element comprising of human physical, experience, attitude and behaviour.

Worksite element is crucial in influencing OSH scenario in the workplace. According to Aneziris, Topali & Papazoglou (2011) and Pinto, Nunes & Ribeiro (2011), construction industry has been concluded as dangerous and high risks due to unsafe and complicated worksite environment. This element is comprised of worksite condition, poor site management, equipment & material and construction tasks.

Underlying factor contribute to OSH incidents by indirectly elevating the risks. In this factor, there are two main elements consisting of management and external. Both of the elements can be considered as distant or less obvious during investigations. Underlying factor involved in more than 90% of the occupational accidents that was investigated in construction industry (Haslam *et al*., 2005). Through the numbers, it can be concluded that this factor has a big impact towards accidents in construction industry.

Inefficient OSH management in construction industry will increase the risks of occupational accidents and illnesses to occur in construction industry. 98% of occupational accidents in the industry can be prevented at management level (Abudayyeh, Fredericks, Butt & Shaar, 2006). Although as one of the underlying factor that majorly contributing to OSH incidents in the industry, management element tend to be neglected or ignored as investigations are concentrating on immediate causes (Filho, Fonseca, Lima & Duarte, 2012). Management element which inclusive of policy, resource management, management culture and safety management aspects plays a significant role in contributing to accidents in the construction industry.

The external element can be categorized into three sub-elements comprising of political and legislation, economy as well as social. This element contributed to occupational incidents similarly to management element but it comprises of a bigger scope. It includes external organizations that are working together in the construction industry. External element is the most distant causes of OSH incidents.

1.4 Occupational accidents in construction industry

OSH in construction industry focuses extensively on accidents rather than illnesses. There are four types of accidents that need to be prioritized in construction industry. These accidents are falling from height, electrocution, struck-by, and caught in/between (Hinze and Russell, 1995; Reese and Eidson, 1999; Ling, Liu & Moo, 2009). All these accidents are the highest contributor to fatalities in construction industry. Out of the mentioned accidents, falling from elevation possessed the highest risk and has recorded the largest number of injuries and fatalities cases in construction industry (Cattledge, Hendricks & Stanevich, 1996; Janicak 1997; Chi, Chang & Ting, 2005; Dong, Fujimoto, Ringen & Men, 2009; Schwatka, Butler and Rosecrance 2012**;** Zhang *et al*., 2015).

Lack of concentration being given on occupational health aspect in construction industry because the nature of illnesses is less immediate and notable compare to accidents (Reese and Eidson, 1999; Holt, 2006). However, it doesn't mean that occupational illnesses should be disregard because it still poses long term risks which are fatal such as chronic diseases.

1.5 Construction OSH management framework

An OSH management framework based on Teo, Ling & Chong (2005) and Teo and Ling (2006) for managing construction safetyconsisting of policy, process, personnel and incentive elements was improvised with some changes in the sub-elements. The changes were made from literature review of previous works and Malaysian standards of OSH management systems (Malaysian Standard 2011). Table 3 provide the definition of each element that was proposed according to Teo *et al*. 2005, while Figure 1 illustrated the items that were included for all the elements.

Table 3: Definition of the management elements

ELEMENT	DEFINITION
Policy	Items related to regulation and legislation that forms a framework in which OSH is regulated and controlled through safety legislation and policies which are able to impact safety level at the construction site.
Process	Managing the process of carrying out tasks by construction personnel that may eventually be harmful to their well being and safety.
Personnel	The personnel element is characterized by the aspects of human that are presence in construction activities related to safety behaviour and attitudes of management as well as workers.
Incentive	Part of the program in motivating personnel to adhere to rules and regulation to reduce OSH risks through monetary and non-monetary incentives as well as disciplinary action

Figure 1: Construction OSH management framework

2.0 Methodology

Residential construction industry was chosen for this study due to its versatility in construction approaches depending on type of residential that are being constructed. High-rise and low-rise residential construction projects demand different level of OSH management. The island area of Pulau Pinang was

chosen as the location of study due to high demands of residential needs and preference in developing high-rise projects.

Number of fatalities related to construction industry generally is excruciating. According to DOSH (2015) within 2012-2014, construction industry dominates the number of fatalities with 66.67% in 2012, 50% in 2013 and 66.67% in 2014. It shows that construction industry in Pulau Pinang is in a dreadful condition.

A total of 13 housing construction projects in Pulau Pinang, Malaysia have been chosen. There are seven high-rise and six low-rise housing projects that have been selected according to a few conditions. All the projects have been listed with Ministry of Urban Wellbeing, Housing and Local Government of Malaysia and fulfil the definition of housing development according to Housing Development (Control and Licensing) Act 1966 - Act 118. These projects are not mixed in nature and construction commenced before December 2013.

13 respondents were selected for in-depth interview. One respondent was chosen from each housing construction projects. These respondents can be classified as personnel at management level that responsible in making decisions regarding the aspect of occupational safety and health at the construction sites. In Malaysia, it is optional to hire an occupational safety and health officer (SHO) for construction project lower than RM 20M. Therefore for project without SHO, project managers were interviewed. Eight of the respondents were SHO and the other five respondents were project manager. Theory thematic analysis was utilized in analyzing the results of the interview.

3.0 Results And Discussion

The interviews that were conducted comprising of factors contributing to occupational accidents and illnesses; risk of occupational accidents; and OSH management in construction industry. Results and discussion regarding contributing factors of occupational accidents and illnesses as well as construction OSH management is presented.

3.1 Contributing factors towards construction occupational accidents and illnesses from the perception of Malaysian residential construction industry

The factors contributing to occupational accidents and illnesses in construction industry consisting of human, worksite, management and external elements were studied from the perception of Malaysian residential construction industry.

i. Human element

Human element as a contributing factor is considered as crucial in the aspect of occupational incidences at construction site. Almost all respondents classified that this element is very significant. Three respondents mentioned that most of the occupational accidents at site could be associated with human.

In terms of human physical, it does contribute to occupational accidents at site but it can be deemed as not a dominant factor. Two of the respondents stated that health issues including having unhealthy or unfit employees as well as employees under the influences of drugs and alcohol to be continuing their task at site.

Most of the respondents believed that experience including knowledge is an important sub-element in contributing to occupational accidents at site. 11 respondents justified that lack of knowledge and experience in terms of their tasks and the risks of accidents at site proved to be vital. Due to lack of knowledge in terms of accidents risk, the employees are less aware of it and at the same time affecting their decision-making as well as the assessment towards their task. This was also mentioned by Choudry, Fang and Ahmed (2008), as risks of occupational accidents and illnesses could increase if employees are not being exposed to enough information and experience.

Six respondents stated that attitude is an important sub-element in contributing to occupational accidents in the construction industry. More than half of the respondents agreed that employees tend to neglect OSH issues and ignore the occupational accidents risk. Employees attitude towards OSH play a significant role in achieving good safety performance in construction industry (Sulastre Mat Zain and Faridah Ismail, 2012).

Eight respondents concluded that behavioural factor is an essential contributing factor towards occupational accidents in the industry. Negligence is believed to be the biggest contributor in this sub-element by more than half of the respondents. Negligence is the cause of accidents that relates with unsafe and unsuitable acts (Chi, Han and Kim 2013). It was also stated that some employees still decided to make irresponsible decisions, although they understand

the risk. Among the factors leading to this scenario is generally construction industry tend to focus on progress of a project.

ii.Worksite element

From the interview, a few of the respondents stated that worksite element should be considered as an important contributing factor but not as significant as human element. One of the respondent added that proper management is important in reducing the risks of occupational incidences from this element.

The first sub-element is worksite condition. Eight respondents associated the aspect of weather as crucial at sites. Four respondents mentioned that the probability of heat stroke due to working in excessive heat condition. Meanwhile, seven respondents talked about the after-effect of rain towards worksite condition which leads to unsafe situation. Working condition related to noise and ventilation is also important. It was stated that there is a significant number of accidents related to struck-by object or vehicle and machine due to miscommunication (warning and signal) which causes by noise (Suter, 2002).

The second sub-element is poor site management. All the respondents correlated this sub-element with poor housekeeping (cleanliness and arrangement). It shows that housekeeping is a crucial element in producing safer worksite.Three respondents stated that poor arrangements at site will lead to accidents. On the other hand, two respondents associated cleanliness impact towards health of the construction personnel.

The third sub-element is equipment and material. From the perspective of Malaysian residential construction industry, it is not a major aspect. Two respondents mentioned that management failure in providing proper quality tools may increase the risks of accidents. Meanwhile, two respondents stated that poor quality and lack of maintenance of the machineries proved to have the same impact. One respondent raised up the point that unsuitable and poor quality construction materials may contribute to accidents at site.

The final sub-element is construction tasks. Through the interview, this is the less significant sub-element. Two respondents mentioned the needs to work at elevated level are creating risks of falling. One respondent stated that various works involving various people simultaneously lead to higher risks of accidents.

iii.Management element

Management element is the first underlying contributing factor that was tested in this study. Five respondents concluded that weakness of management in managing OSH at sites is crucial. It shows that influence from management level is important in creating a safer working condition. Three respondents stated that management influence towards occupational accidents is indirect.

The first sub-element is the OSH policy. Through the interview, it should be considered as the less significant. One respondent raised up the issue of not having proper aims and objectives in managing OSH. It reflected that lack of awareness and poor perception of OSH at management level.

The second sub-element is resource management that includes finance, time and personnel. 12 respondents gave their views on this sub-element. 10 respondents associated the influence of having insufficient budget in order to manage OSH at site. Although every organization do have the capabilities to prevent accidents, it will be difficult due to implication of the budget provided in actual scenario (Aminbakhsh, Gunduz & Sonmez, 2013). Nine respondents stated that inefficient management of personnel contributes to poor OSH management. Among the reasons are personnel recruitment and sub-contractor hiring do not prioritize OSH as well as lack of competent personnel. Three respondents mentioned that insufficient time given in completing construction tasks is also a contributing factor in this sub-element.

The third sub-element is the component of safety management. Six respondents reacted regarding lack of monitoring on construction personnel in doing their tasks. Effective communication in monitoring activities is important in enhancing employees OSH performances in construction industry (Aminbakhsh, Gunduz & Sonmez, 2013). One of the respondents also mentioned the aspect of insufficient training given to personnel.

The final sub-element is the management culture which also being deemed significant by the respondents for this management element. In this sub-element, the progress of a project (including duration of work) is being perceived as more important than OSH by six respondents is one of the contributors to occupational accidents. Five respondents considered that accentuation of financial factor including profit over OSH might increase the risks of occupational accidents. Three respondents mentioned that preference of quality of a project over OSH will also lead to occupational

accidents in the industry. Interestingly, two respondents stated that management in smaller scale or low-rise projects tend to disregard OSH management due its low risks nature.

iv.External element

External element is the last element that was tested in this study regarding the contributing factor of OSH accidents in construction industry. Three respondents stated that this element is an underlying contributor. Two of them mentioned that this element is considered as less significant. However, this might be a wrong perception of the external element because its influence although unclear is still significant in increasing the risks of the immediate contributing factors.

The first sub-element is legislation and politic. Firstly, seven respondents reckoned that the existing legislation can be considered as sufficient in regulating OSH in the Malaysian construction industry. However, nine respondents decided that enforcement of the legislation need to be improved. Among the comments related to this issue are enforcement is not being done consistently and efficiently as well as less pressure from regulators. Although legislation deemed to be sufficient, cost and time needed in implementing it are being considered as high. This is one of the reasons that discourage project management team in implementing OSH at site. There are also two respondents that associated the duration of approval regarding OSH matters from regulator is too long. One respondent also mentioned that some of the regulator officers do not have enough knowledge regarding the actual construction process.

Four respondents agreed that the second sub-element (economy) is not a significant contributor of accidents in the construction industry. This sub-element is also being considered indirect contributor to accidents. One of the respondent stated that in an unstable economy condition, OSH budget might be cut and will have a negative impact on OSH performance at site. The final sub-element is social impact which includes the developer (client) and the community. The developers do not give enough attention to OSH management. It might lead to poor OSH performances at site. Involvement of developer (client) in reducing number of accidents is significant (Huang and Hinze, 2006).Table 4 shows the summary of the interview findings concerning factors contributing to occupational accidents and illnesses in the construction industry from the perception of Malaysian residential construction industry.

Table 4: Human element in contributing to occupational accidents and illnesses

Human physical	Human physical factor contribute to occupational accidents (3 respondents). This factor related to health as well as working under the influences of drugs and alcohol (2 respondents). This factor is not that dominant (1 respondent).
Experience (inclusive of knowledge)	Lack of knowledge/ information/ experience contributing to occupational accidents (11 respondents). Lack of awareness or negligence or poor risk assessment due to lack of experience factor (3 respondents).
Attitude	Attitude is the biggest contributor (6 respondents). Construction personnel tend to neglect OSH (8 respondents). Overconfidence leading to negligence (2 respondents)
Behaviour	Behaviour is a significant contributor (8 respondents). Negligence (unintentional unsafe act) (8 respondents). Intentional unsafe act (3 respondents).

Table 5: Worksite element in contributing to occupational accidents and illnesses

Worksite condition	Weather is a contributor to occupational accidents and illnesses (8 respondents).	After effect of rain (7 respondents). Excessive heat (4 respondents).
	Noise and ventilation (1 respondent).	
Poor site management	Housekeeping (cleanliness and tidiness) (13 respondents).	
	Tidiness and poor site arrangement leading to occupational accidents (3 respondents)	
	Site cleanliness leads to health issues (2 respondents).	
Equipment and material	Poor quality of tools (2 respondents).	
	Lack of maintenance and poor quality machineries (2 respondents).	
	Unsuitable and poor quality construction materials (1 respondent).	
Construction tasks	The need to work at elevated level (2 respondents).	
	Various works involving various people simultaneously (2 respondents).	

Table 6: Management element in contributing to occupational accidents and illnesses

OSH policy	Issue of not having proper aims and objectives in managing OSH (1 respondent).	
Resources management	Lack and poor management of OSH budget (10 respondents).	
	Inefficient management of personnel contributes to poor OSH management (9 respondents).	Personnel recruitment and sub-contractor hiring do not prioritize OSH (4 respondents) Lack of competent personnel (3 respondents).
Safety management	Lack of monitoring (6 respondents).	
	Lack of training (1 respondent).	
Management culture	Prioritizing time and progress over OSH (6 respondents).	
	Prioritizing monetary factor and profit over OSH (5 respondents).	
	Prioritizing quality over OSH (3 respondents).	
	Neglecting OSH due to low risk of occupational accidents and illnesses (1 respondent).	
	Small scale or low-rise projects tend to neglect OSH (2 respondents).	

Table 7: External element in contributing to occupational accidents and illnesses

Legislation and politic	Lack of enforcement and ineffective enforcement (9 respondents).
	Cost and time needed in implementing it are being considered as high (2 respondents).
	Duration of approval regarding OSH matters from regulator (2 respondents).
	Regulator personnel lack of knowledge on actual construction industry (1 respondent).
Economy	Not a significant contributor of accidents in the construction industry and effecting OSH indirectly (4 respondents).
Social	The developers do not give enough attention to OSH management (2 respondents).

3.2 Construction OSH management from the perception of Malaysian residential construction industry

Referring to Figure 1, those elements (policy, process, personnel and incentive) and sub-elements of the construction management framework was tested. A brief results and discussion were included in this section.

i.Policy

In this element, it was found that all project sites do have their own set of OSH policy. This scenario gives a positive reflection on management commitment in terms of OSH because Reese & Eidson stated that implementation of OSH policy shows constructive commitment and leadership in managing OSH. Although implementation of legislation deemed as important by 12 respondents, only three respondents think that its implementation can be considered as good at their respective sites. While nine respondents considered their implementation as sufficient, one respondent felt that his site performance on this matter is insufficient. In order to improve the implementation of legislation at sites, regulator need to provide sufficient legislation and followed by effective enforcement (Tam, Zeng & Deng, 2004).

ii.Process

From the perspective of Malaysian residential construction industry, a few sub-elements were perceived as major in this element. There are sub-contractor management (12 respondents), hazard and risk assessment (12 respondents), safety working procedure (11 respondents), and communication (10 respondents). Sub-contractor OSH performance is influence by time, financial, nature of the tasks, pressure from the main contractor and relationship between the sub-contractors (Wadick, 2010). Hazard and risk assessment is an important instrument that could reduce number of occupational accidents in the industry and useful in producing an effective OSH management programme.

iii.Personnel

In the process element, two sub-elements were perceived as important by Malaysian residential construction industry. The first sub-element is management commitment. All 13 respondents agreed that management commitment is crucial in developing an effective OSH programme. Safety aspect needs to be moulded as a culture through definite commitment at management level (Abudayyeh, Fredericks, Butt & Shaar, 2006). Commitment at employee level is also crucial because this group of people are consistently being exposed to OSH risks in the industry. 10 respondents stated that it is a major aspect of producing an effective safety programme.

iv.Incentive

Incentive element is consisting of incentive programme (monetary and non-monetary) and disciplinary system. Mixed reaction was received from the respondents regarding this element. 10 respondents agreed that disciplinary system is effective, while six respondents stated the same opinion for incentive programme. Six respondents preferred disciplinary system over incentive programme and only two respondents have an opposite preference. However, one respondent concluded that both of these approaches need to be implemented simultaneously to achieve the best result. Disciplinary program is implemented in all the projects that were visited.

4.0 Conclusion

Fatalities in Malaysian construction industry are an issue that need to be resolved. It leads to loss of resources including monetary, time and personnel. These fatalities will not just have an impact on the industry but socio-economic impact on the family members of the victims. Malaysian construction industry also needs to be educated in terms of occupational accidents and illnesses reporting. It is important that it becomes a practice in the industry. It will be beneficial for the industry to have such information in developing effective OSH legislation and management programme.

Contributing factors of occupational accidents and illnesses in construction industry consist of four main elements (human, worksite, management and external). From the perspective of Malaysian residential construction industry, the findings are in line with the literature. Human and worksite elements are considered as contributing factors that are immediate, while management and external elements contribute indirectly. However, it is important to identify these elements, in order to mitigating occupational accidents and illnesses. During investigation, all these contributing factors need to be identified and resolved. It will help in reducing the risks of reoccurrence. If the focus is being concentrated just on the immediate elements, then the risks of occupational accidents illnesses could not be reduced significantly.

Developing and implementing an effective OSH management programme in the construction industry is a challenge. There are many factors that need to be focused on. Having sufficient legislation is not enough if there is no proper

implementation being done at site. Regulator also needs to put pressure on the construction industry to obtain positive results. However, it is important to develop a safety culture in the industry itself. Otherwise, OSH will be another burden to the organization implementing it because a lot of resources (finance, time and personnel) are required to be utilized. Therefore, it is vital that commitment from the regulator, financier, supplier, developer, consultant, contractor and labour is needed to initiate the safety culture in the industry.

With all the commitments from all sectors of construction industry, developing and implementing an effective program will be simple. At this stage, suitable and required instruments of construction OSH management need to be selected and implemented according to the risks exposed to the construction personnel.

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Malaysian Construction Industry: Trends of Occupational Accidents from 2006 to 2015

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Abstract: *The construction industry is one of the largest sectors in Malaysia. This industry has become one of the main contributors for national economic development and consistently contributes 3% to 5% to the national Gross Domestic Product (GDP). This sector has also opened up job opportunities for various levels of employment. High demands and rapid urbanization offer huge opportunities for registered contractors. Despite contributing in enhancing national economics, this sector has been regarded as one of the most dangerous and hazardous workplaces due to the type of nature and the job activities at construction sites. According to the International Labour Organization (ILO), 2.3 million fatalities related to occupational accidents and illnesses are estimated to occur each year. Furthermore, 4 percent of world GDP is estimated to be lost due to occupational accidents and illnesses. The number of fatality accidents in the construction industry was the highest with 652 cases of non-permanent disability (NPD) and permanent disability (PD) accidents in the period 2007 to 2015, equivalent to 72.44 cases per year and representing 48.77% of the construction industry. The huge gap between the number of accidents reported to SOCSO and DOSH becomes a major concern due to a rising number of underreported cases of fatalities and injury in the construction sector, especially those involving foreign labour. The margin between accidents reported to SOCSO and DOSH is 97.49%. Regards to rapid developments, safety measures to improve performance management of OSH should be emphasized to reduce losses of life, property and productivity.*

Keywords: *construction fatalities, construction accident, underreporting accident, construction safety, Malaysian construction safety*

1.0 Introduction

Increasing demand for construction activities makes the construction industry one of the biggest contributors to Malaysia's development process and economic growth (Dayang Nailul Munna Abang Abdullah & Gloria Chai Mei Wern, 2011). In addition, the construction sector is one of the sub-sectors of the economy that generates the country's main sectors, which are agriculture, industry and services, and thus has a great impact on the Malaysian economy (Md Zyadi bin Md Tahir *et al*., 2009). Construction is also considered as an active and booming industry worldwide, and has been recognized as one of the major economic forces contributing enormously towards achieving the Malaysian target to become a developed nation by the year 2020 (Syamsul Hendra Mahmud & Roslan Amirudin, 2015). Contractor employment also increases each year in order to fulfil the demand for construction activities. Before any local or foreign contractors can undertake any projects and commence any construction works to completion in Malaysia, they are required to register with Construction Industry Development Board Malaysia (CIDB) (Che Azizah Abdul Rahman *et al*., 2013).

Occupational safety and health has recently become a major concern across many different employment sectors in Malaysia, following increasing evidence of enormous loss, illnesses, disabilities and suffering caused by occupational diseases and ill health. According to the International Labour Organization (ILO, 2014), it is estimated that 2.3 million fatalities occur annually due to work-related accidents and disease, as well as a much higher number of workers who suffer from non-fatal injuries and illnesses (ILO, 2014).Unreported accident cases in the industrial sector, especially in the construction sector, are another emerging major concern. Along with the rising number of foreign labourers in Malaysia, both with and without permits, the actual number of accidents in the construction sector could be higher than what is actually reported (Abdul Rahim Abdul Hamid, Muhd Zaimi Abd Majid, & Bachan Sigh, 2008).

This manuscript is intended to review the trend of occupational accidents in Malaysian construction industry. Firstly, scenario of construction industry in Malaysia inclusive of its contribution, trend of projects being awarded and contractors' enrolment was reviewed. It will give an overview of Malaysian construction industry.

Latter in the manuscript the trends of occupational accidents in the industry were discussed. This was a time-trend series study that included cases of occupational accidents recorded in official statistic website such as Department of Occupational Safety and Health Malaysia (DOSH) and Social Security Organization Malaysia (SOCSO). An overview

of the occupational accidents statistic for all industries was presented in order to show its trend in Malaysia. It is followed by the presentation of trends of occupational accidents in the context of Malaysian construction industry. The component of under-reporting was also included in the manuscript to further explain the trends presented earlier.

2.0 Methodology

The research has been conducted through several phases, namely data collection, data analysis, discussion and conclusion. The data required for this study was obtained from the Department of Occupational Safety and Health Malaysia (DOSH), Social Security Organization Malaysia (SOCSO), Economic Planning Unit and Construction Industry Development Berhad (CIDB) through official websites, annual reports and statistical reports. Those relevant documents were examined thoroughly and all the numbers of counts were calculated.

This manuscript was prepared by collecting the secondary data and interpreting the data via descriptive analysis. The analysis of secondary data or relevant information was based on and other similar research related to the cause of occupational accidents especially in the construction industry. The existing journals that were used in this manuscript are found through Google scholar and respected journal databases (Elsevier, Wiley, ASCE library and etc.). The main key phrases being used in searching the information were "construction safety", "grade contractor", "construction industry" and "construction accidents".

Additionally, the data collected in this manuscript only covered the number of occupational accidents in the construction industry. The online data retrieved was available and uploaded in the website from 2007 to 2015 in the time this manuscript was written. Quantitative data were converted in the form of bar charts and tables to make the analysis easier and more comprehensible. This manuscript only describes the cases of accidents that were reported by DOSH and SOCSO.

3.0 Scenario of Construction Industry in Malaysia

The construction industry has been a substantial and important driver of Malaysia's economic growth and has recorded double digit growth over the last few years (Construction Industry Development Board [CIDB], 2015).

3.1 The Importance and Contribution of the Construction Industry in Malaysia

The Malaysian construction industry plays a very important role in providing the necessary infrastructure for socio-economic development and contributes directly to the improvement of the national economy (Fadhlin Abdullah *et al*., 2004). The economic growth related to the construction sector, finance and infrastructure have long-term relationships in the country's economy (Md Zyadi *et al*., 2009). In addition, the construction sector has also provided job opportunities for people in the professional field such as architects, engineers, contractors, sub-contractors, suppliers and also labourers (Lim Chong Fong, 2005).

Referring to the document of the 10th Malaysian Plan (MP-10) (Economic Planning Unit, 2010), Gross Domestic Product (GDP) for the construction sector under the 9th Malaysian Plan (MP-9) and MP-10 can be seen in Table 1. From the Table 1, the GDP for year 2006 to 2009 shows the increasing number of actual constant price with an average annual growth rate of 4.4%. This expansion shows an increase of 1.1%, which was obtained through the 8th Malaysian Plan (MP-8). The estimation of constant price for the year 2010 is RM 18, 187. The growth rate of GDP for the construction industry ranks at the second highest after services sector. Increasing growth rate only occurred for the construction and services sectors, while other sectors such as manufacturing, agriculture and mining showed a decreasing growth rate.

Table 1: GDP for the construction sector under the MP-9 and MP-10

	Year	Constant price for 2000 (RM million)	Average annual Growth Rate (%)	
Actual	2006	14640	4.4	MP-9
	2007	15707		
	2008	16366		
	2009	17321		
Estimate	2010	18,187		
Target	2012	19775	3.7	MP-10
	2015	21818		

(Economic Planning Unit, 2010)

Meanwhile, the growth rate target for MP-10 (2011-2015) was 3.7% with the end figure for year 2015 at RM 21, 818 million. Overall, the construction sector is estimated to achieve the second highest growth in MP-9 and was targeted as the third highest in MP-10 (Economic Planning Unit 2010). This shows that the construction sector is one of the fastest developing sectors in Malaysia. Construction output and GDP have a positive correlation and the annual rate of increase followed the trend of economic growth (Fadhlin Abdullah *et al*., 2004).

According to Table 2, the states that had the highest constant prices for 2010 (estimate) and 2015 (forecast) were Selangor, Kuala Lumpur, Johor, Sarawak and Pulau Pinang. Referring to the estimates made for the MP-9, Terengganu (8.5%), Labuan (8.4%), Sabah (8.4%), Perlis (7.1%) and Selangor (7.0%) had the highest average annual growth rate. Meanwhile, according to the forecast for MP-10, Terengganu (6.7%), Labuan (5.5%), Perlis (5.4%), Melaka (5.0%), Kedah (4.9%) and Kelantan (4.9%) recorded the highest growth rate. However, all states recorded lowest average annual rates for MP-10 compared to MP-9.

Table 2: GDP for the construction industry by state in the MP-9 and MP-10

States	Constant price for 2000(RM million)		Average Annual Increase Rate (%)	
	2010 (Estimate)	2015 (Forecast)	MP-9 (Estimate)	MP-10 (Forecast)
Johor	1954	2384	5.2	4.1
Kedah	591	750	5.4	4.9
Kelantan	189	239	4.7	4.9
Melaka	351	449	5.2	5.0
Negeri Sembilan	508	619	6.2	4.0
Pahang	628	751	6.3	3.6
Perak	680	777	3.0	2.7
Perlis	100	129	7.1	5.4
Pulau Pinang	922	1154	5.7	4.6
Sabah	804	918	8.4	2.7
Sarawak	1262	1579	6.9	4.6

Selangor	6581	7740	7.0	3.3
Terengganu	567	783	8.5	6.7
WP Kuala Lumpur	3025	3513	6.8	3.0
WP Labuan	26	34	8.4	5.5

(Economic Planning Unit, 2010)

As stated earlier, the construction industry plays a very important role in improving the country's economy. In MP-10, the role of the construction sector can be seen clearly. Various arrangements have been made in achieving the objective of becoming a developed and high-income country. The government is trying to catalyse cooperation with the private sector through a new phase of privatization, which includes the construction sector, in order to hasten the transformation of the state towards a high-income economy. The government also intends to expand investment in emerging markets such as Asia, Africa and the Middle East and expand the scope of investment to the construction and services sectors. MP-10 also highlighted new strategies in promoting the country's construction industry at the international level by providing support and amending legislation to facilitate the relationship between the governments that are involved. In addition, the importance of the construction industry in MP-10 is believed to contribute towards other sectors. Among the contributions that have been identified are presented in Table 3.

Table 3: Construction industry in other sectors of the MP-10

Industry	Subject
Education	Expansion of trainer intake in technical and vocational institution on the raising of 10 training institutions subsequently and improvement of 16 existing training institution. Construction grants to the private sector to build a preschool in the less developed areas outside the city.
Infrastructure	Construction of toll highways and power plants. Construction and upgrading of rural basic infrastructure (roads, water and electricity). Construction of the Integrated Transport Terminal in Bandar Tasik Selatan Construction of the city road in an effort to reduce traffic problems in major cities.
Health	Establishment of 39 new health clinics and 81 new clinics in the rural areas.
Housing	Improve rural area Construction of adequate, quality and affordable houses

(Economic Planning Unit, 2010)

The construction industry provides job opportunities at all levels, from the workers at the construction site to the professionals at the office (Huth, 2008). Table 4 shows the man power used in the construction sector under the MP-9 and MP-10. In year 2010, the estimated number of employment in the construction sector was 765,400, equivalent to 6.5% of total employment for that year. The number of employees in the construction sector is targeted to expand in 2012 and 2015. However, the percentage target shows the declining number at 5.9% in 2015. Meanwhile, the number of job creation targeted in the MP-10 is 11,100, which exceeds almost half of the total job creation in the MP-9 (5,800). According to Abdul Razak Ibrahim *et al*. (2010), construction industry in Malaysia has a great influence in providing job opportunities at national level.

Table 4: Employment number in construction sector in MP-9 and Mp-10

	Year	Number of Employment (1000 people)	Job creation ('000)	Average Annual Increase Rate (%)	
Actual	2006	755.2 (6.8%)	5.8	0.2	MP-9
	2007	757.3 (6.6%)			
	2008	758.4 (6.6%)			
	2009	762.4 (6.6%)			
Estimate	2010	765.4 (6.5%)			
Target	2012	770.7 (6.2%)	11.1	0.3	MP-10
	2015	776.5 (5.9%)			

(Economic Planning Unit, 2010)

3.2 Contractor Enrolment and Project Development Scenario

The contractor plays a very important part in the construction industry. Poor standards of performance and quality by contracting parties are among the main factors affecting performance in the construction industry worldwide (Md Asrul Nasid Masrom & Skitmore, 2010). In Malaysia, all contractors need to register under the Construction Industry Development Board (CIDB), who will be subsequently classified into seven grades based on their tendering capacity and paid up capital (Theong, Tan, & Ang, 2014).

Table 5 shows the number of contractors registered at the end period of each year (2009-2013). During the period of time which has been recorded, the highest number of registered contractors was registered in 2012 (69,490) compared to the lowest number in 2011 (63,850). This amount covers all grades of contractors involved. From the aspect of contractor-grade enrolment, the lowest numbers of contractors for year 2009 until 2013 are from grade G4, G5, G6 and G7. Those four grades cover 18.61% (2009), 19.77% (2010), 19.54% (2011), 20.25% (2012) and 21.14% (2013) of the total contractors who registered each year. Meanwhile, the highest number of contractors who registered by more than 50% each year is under grade G1.

Table 5: Number of contractors registered at the end of period each year

Year	Number of contractors registered at the end of period each year
2009	64758
2010	64593
2011	63850
2012	69490
2013	66672

(CIDB, 2010, 2011, 2012, 2013 & 2014)

Table 6 shows the contractor's classification in Malaysia by CIDB based on the tendering capacity, paid-up capital and the size of the company. According to Erni Mustafa Kamal, Syarmila Hany Haron, Norhidayah Md Ulang, & Faizal Baharum (2012), this high number is related to the minimum paid-up capital of only RM5, 000 and the contractors are allowed to undertake the projects up to RM 200,000. These minimum requirements allow many contractors which have minimal disbursement to have higher chances to register as G1 contractors (Che Azizah Abdul Rahman *et al*., 2013).A contractor can upgrade to higher grade when the company has a good stand on their financial capabilities (Erni Mustafa Kamal & Flanagan, 2014). G1 to G3 contractors fall under the small-size company category, while G4 and G5 contractors are categorized as medium-sized companies and G6 and G7 contractors are categorized as large-size companies.

Table 6: Contractor's classification in Malaysia by CIDB

Contractor Grades of Registration	Tendering Capacity	Paid-Up Capital	Size of Company
G7	No limit	RM 750,000 (USD 247,500)	Large
G6	Not exceeding RM10 million (USD 3.3 million)	RM 500,000 (USD 165,000	Large
G5	Not exceeding RM 5 million (USD 1.65 million)	RM 250,000 (USD 82,500)	Medium
G4	Not exceeding RM 3 million (USD 990,000)	RM 150,000 (USD 49,500)	Medium
G3	Not exceeding RM 1 million (USD 330,000)	RM 50,000 (USD 16,500)	Small
G2	Not exceeding RM500, 000 (USD 165,000)	RM 25,000 (USD 8,250)	Small
G1	Not exceeding RM200, 000 (USD 66,000)	RM 5,000 (USD 1,650)	Small

(Theong, Tan & Ang, 2014)

Figure 1 shows the percentage of registered contractors by grade enrolment at the end of each year. G1 contractors monopolize the number of registered contractors, accounting for more than 50% of the total. As of June 2014, a total of 6193 (29.9%) new contractors were registered (CIDB, 2014). In contrast, 6,295 (9.44%) contractors have been declared dormant or inactive. In terms of grade enrolment, the highest number of dormant contractors is G1 with3363 and the lowest number of dormant contractors is G6 with105.

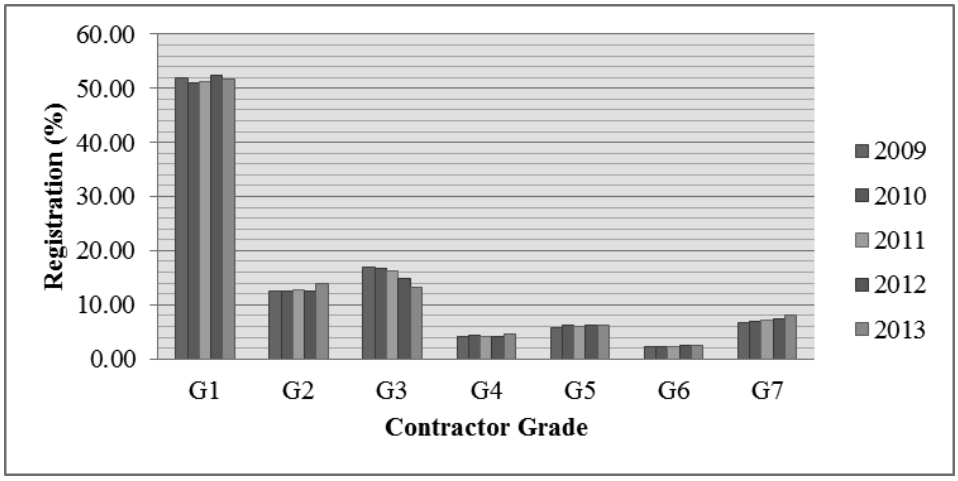

Figure1: The percentage of registered contractors by grade enrolment at the end of each year (CIDB, 2010, 2011, 2012, 2013 & 2014)

According to Theong, Tan, & Ang (2014), this scenario is due to most of the small and medium size contractor registered as G1 contractors failing to earn sufficient attention from the Government. In addition, the status quo is still dominated by large firms in Malaysia which are mainly registered as G6 or G7 grade contractor. This state of affairs has raised considerable concern among lower grade contractors about their sustainability in such a competitive industry.

Meanwhile, in terms of number of dormant contractors in each grade enrolment, G4 had the highest percentage of 10.85%, while G6 (6.90%) and G7 (6.85%) had the lowest percentages. This shows that the percentage of dormant contractors for the two grades of contractors with the capability to enter the highest tender is low. Competition between

contractors in Malaysia is very high and the highest numbers of companies which have been declared bankrupt are from the construction sector (Halim *et al*., 2014).

Due to the large amount of small and medium contractors in Malaysia, the competition for tenders is very high and often lead to business failure (Mastura Jaafar & Abdul-Rashid Abdul-Aziz, 2014). In Malaysia, the construction sector involves long chains of sub-contracting which are dominated by larger companies who in turn appoint small companies as sub-contractors, from various types of job scope, through competitive tendering (Erni Mustafa Kamal, Syarmila Hany Haron, Norhidayah Md Ulang, & Faizal Baharum, 2012). In certain cases, these sub-contractors will appoint other small companies as their sub-contractors to do small tasks. Hence, this culture affects construction work and labour supply on site.

Construction projects in Malaysia are classified into four categories which are residential, non-residential, social amenities and infrastructure (CIDB, 2014). Figure 2 shows that non-residential construction recorded the highest number of projects during the period of 2009 to 2013, followed by residential projects. In contrast, social amenities construction underwent a decrease in the number of projects from 2009 until 2013.

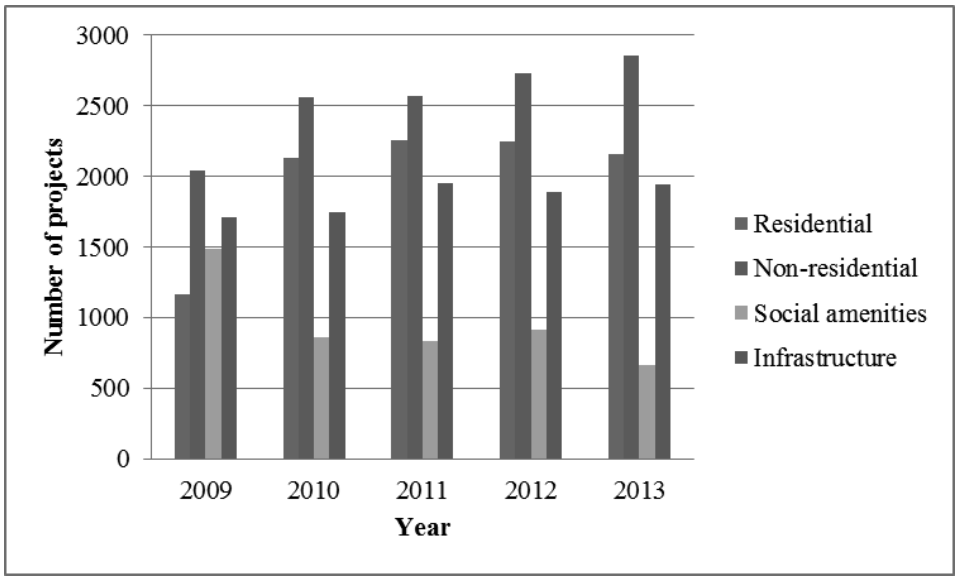

Figure 2: Number of construction projects in Malaysia
(CIDB, 2010, 2011, 2012, 2013 & 2014)

Figure 3 also shows that non-residential and residential category projects consistently increased from 2009 until 2013. Social amenities construction projects, however, showed a decline in number. The number of projects that were registered in 2013 was reduced by more than half since 2009. Correspondingly, the project values also underwent the same trend and decreased by almost half in the same period of time. Infrastructure projects recorded the highest value in 2012 but dropped dramatically to a lower value compared to residential construction projects in 2013.

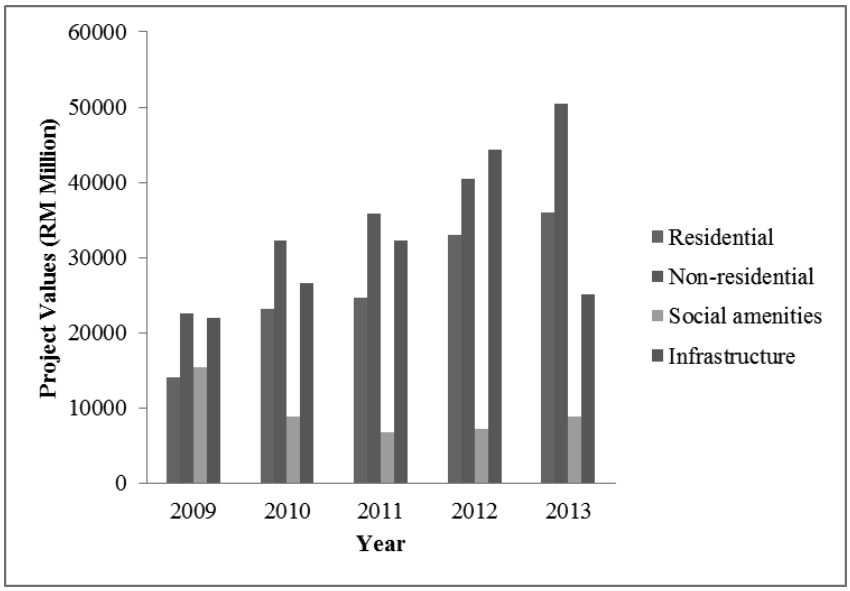

Figure 3: Construction project values in Malaysia (CIDB, 2010, 2011, 2012, 2013 & 2014)

Table 7 shows the number of projects based on states or regions in Malaysia. The highest number of projects between 2009 until 2013 was recorded in the states of Selangor, Johor and Kuala Lumpur. Selangor had 7,509 projects, Johor had 5,834 projects and Kuala Lumpur had 3464 projects during the year 2009-2013. However, Kuala Lumpur was found to have a higher value of the projects compared to Johor although the number of projects in Kuala Lumpur was lower. Meanwhile, Perlis and Kelantan have the lowest number and value of projects over a period of 2009 to 2013 in Malaysia.

This phenomenon is in line with GDP trends which state that Selangor, Kuala Lumpur and Johor have the highest projects values, whereas Kelantan and Perlis have the lowest projects values (Economic Planning Unit, 2010). Table 7 and 8 show the number and value of projects based on states or region in Malaysia.

Table 7: Number of projects in construction sector based on states/region in Malaysia

States	Number of Projects				
	2009	**2010**	**2011**	**2012**	**2013**
Johor	1130	1058	1092	1160	1394
Kedah	300	335	348	306	276
Kelantan	232	144	152	153	140
Melaka	310	322	387	386	320
Negeri Sembilan	296	287	328	344	352
Pahang	426	433	480	554	536
Pulau Pinang	359	482	512	574	523
Perak	457	502	591	599	599
Perlis	91	55	62	55	52
Selangor	1367	1664	1519	1504	1455

Terengganu	310	266	303	337	342
Sabah	595	524	620	476	485
Sarawak	483	486	523	514	476
Kuala Lumpur	542	744	688	819	671

(CIDB, 2010, 2011, 2012, 2013 & 2014)

Table 8: Project values in construction sector based on states/region in Malaysia

States	**Project Values**				
	2009	**2010**	**2011**	**2012**	**2013**
Johor	9219.01	8252.54	11840.71	19717.11	19114.47
Kedah	2137.31	2101.10	2704.93	2630.25	2206.99
Kelantan	1708.67	1234.27	874.00	1254.19	1114.23
Melaka	1822.82	3375.89	3878.22	2853.03	2620.67
Negeri Sembilan	2596.38	2759.35	3611.04	5065.97	4571.21
Pahang	3786.94	5230.60	4529.41	4432.08	4009.95
Pulau Pinang	4576.68	5429.62	5170.53	6487.83	9130.00
Perak	3053.41	3819.43	9415.89	4122.44	3696.39
Perlis	687.49	293.29	296.80	349.87	538.55
Selangor	15164.04	23719.29	22001.99	31545.52	28777.80
Terengganu	3328.35	4572.89	1658.64	3525.15	4823.66
Sabah	9138.35	7041.10	11444.23	6407.55	6507.72
Sarawak	6260.54	8138.76	8519.12	9575.98	15281.50
Kuala Lumpur	10577.91	15040.35	13516.13	27223.27	17983.57

(CIDB, 2010, 2011, 2012, 2013 & 2014)

4.0 Trends of Occupational Accidents in Malaysian Construction Industry

Before presenting the trends of occupational accidents in Malaysian construction industry, it will be beneficial to look at the overview of occupational accidents for all Malaysian industries. It is important to understand the current situation of Malaysian construction industry compared to the other industries in Malaysia.

4.1 Overview of Occupational Accidents in Malaysian Industry

"Occupational accident" is a term related to workplace safety. An accident is an unexpected and undesirable event or occurrence in a sequence of events that result in unintended injury, fatality and property damage. In addition, it will result in industrial injuries (Saravanan Dhanabal, Karmegam Karuppiah, Kulanthayan, Irniza Rasdi, & Sivasankar Sambasivam, 2016). Occupational accidents can not only be devastating in terms of safety and health, but can also give a major impact to daily production depending on the nature of the business due to the costs related to injury and fatality (Pinto *et al*., 2011).

Accidents do not only interrupt daily operations and projects delivered, but also directly and indirectly arouse costs, which could be much higher than the cost to manage a safety program (Tan Chin Keng & Nadeera Abdul Razak, 2014). Moreover, it is estimated that 4 percent of world GDP is lost due to occupational accidents and illnesses

(Nazahah Abd Rahim, Hui-Kim Ng, Bigss, & Boot, 2014). Referring to the statistics of accidents investigated by DOSH from 2007 until 2015, accident-related cases without permanent disability (NPD) recorded the highest number of accidents (21,832 cases) compared to permanent disability (PD) (1,357 cases) and fatal accidents (1,857 cases) for all industries in Malaysia.

Overall, the number of investigated accident cases decreased from 3,395 in 2007 to 2804 in 2014, but dramatically increased in 2015 with 3,345 cases. The lowest number of investigated accident cases was recorded in 2009 (2,386 cases). The lowest number of accidents for NPD accidents (2,054 cases) and PD accidents (108 cases) were also recorded in 2009. For fatal accidents, 2009 recorded the highest number with 214 cases. Meanwhile, the lowest number of fatality cases was recorded in 2011 (176 cases) for the period of 2007 until 2015. This trend shows uncertainty in the number of accidents recorded in the construction sector each year, which is probably due to the fact that the employer did not give sufficient priority on occupational safety and health for their workers, especially towards foreign workers (Hui-Nee, 2014). Table 9 shows the number of accidents investigated by DOSH since 2007.

Table 9: Number of accidents investigated by DOSH for all types of industries

	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Non-permanent Disabilities (NPD)	3008	2134	2054	2157	2089	2440	2476	2456	3009
Permanent Disabilities (PD)	168	162	108	190	164	201	162	144	122
Fatalities	219	239	224	185	176	191	185	204	214
TOTAL	**3395**	**2535**	**2386**	**2532**	**2429**	**2832**	**2823**	**2804**	**3345**

(DOSH, 2008, 2009, 2010, 2011, 2014a, 2014b & 2015)

Table 10 shows the difference in the number of NPD for all types of industries from 2007 until 2015. According to the above table, the most reported cases of non-permanent disabilities was in the manufacturing sector with 14480 cases or 66.30% of total accidents reported for 2007 until 2015. This result may due to the fact that occupational safety culture amongst Malaysian manufacturers is still lacking and is not well incorporated (Noor Aina Amirah, Wan Izatul Asma, Mohd Shaladdin Muda, & Wan Abd Aziz Wan Mohd Amin, 2013).

Table 10: Number of non-permanent disabilities caused by occupational accidents for the year 2007 until 2015

Year	**Non-Permanent Disabilities (NPD)**								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Manufacturing	2094	1585	1419	1493	1471	1533	1469	1510	1906
Mining and Quarrying	5	4	2	2	16	147	30	43	32
Construction	76	56	38	50	43	40	83	94	138
Agriculture, Forestry, Logging and Fishery	712	368	440	467	365	385	488	441	440
Utility	51	83	116	34	45	86	100	69	86
Transport, Storage & Communication	7	18	21	16	39	86	84	84	107
Wholesale and Retail Trade	11	2	0	0	13	61	66	74	102
Hotel and Restaurant	11	13	18	25	7	14	19	56	62

Financial, Insurance, Real Estate & Business Services	25	2	0	30	31	57	70	65	105
Public Services and Statutory Bodies	16	3	0	40	59	49	67	20	31

(DOSH, 2008, 2009, 2010, 2011, 2014a, 2014b & 2015)

Meanwhile, the lowest number of cases was recorded in the hotel and restaurant sector with a total of 225 cases, or 1.03% of total reported cases. For the construction sector, the number of reported accidents which resulted in NPD injury is 618 or 2.83%. This statistical data shows that, the number of investigated cases involving NPD injury shows a decrease from 2007 and plots a stagnant pattern starting from 2008 onwards. This pattern can be seen in Figure 4 below.

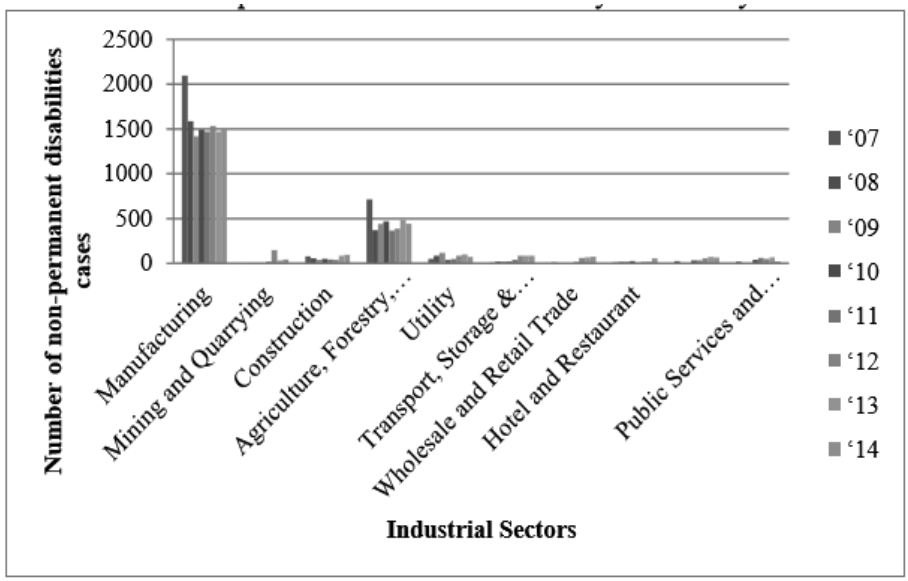

Figure 4: Number of non-permanent disabilities cases by sector for year 2007 until 2015 (DOSH, 2008, 2009, 2010, 2011, 2014a, 2014b & 2015)

Permanent disability injuries can impose severe impacts on workers' quality of life, families, employer, economy and also society (Russell, Maître, & Watson, 2015). For example, the injuries or illnesses may reduce household income and may force other household family members to leave the job to care for the disabled family member. Table 11, shows the number of PD reported for all industrial sectors from 2007 until 2015.

Table 11: Number of permanent disabilities caused by occupational accidents for the year 2007 until 2015

Year	Permanent Disabilities (PD)								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Manufacturing	133	136	90	162	133	147	128	122	89
Mining and Quarrying	1	0	1	1	0	0	0	4	3
Construction	10	3	6	2	5	12	12	6	11
Agriculture, Forestry, Logging and Fishery	14	7	8	18	12	26	14	9	9
Utility	4	12	3	3	3	0	0	1	4

Transport, Storage & Communication	0	1	0	1	6	5	1	3	2
Wholesale and Retail Trade	1	0	0	0	3	6	7	3	3
Hotel and Restaurant	2	1	0	0	1	1	0	0	0
Financial, Insurance, Real Estate & Business Services	0	1	0	2	0	3	0	5	0
Public Services and Statutory Bodies	3	1	0	1	1	1	0	1	1

(DOSH, 2008, 2009, 2010, 2011, 2014a, 2014b & 2015)

According to the table above, the manufacturing industries recorded the highest number of accidents resulting in PD injuries with 1140 cases or 79.66% for 2007 until 2015. Agriculture, logging, and fishery falls into second place with a recorded number of 117 cases or 8.18%, which was probably due to increased participation of foreign labour and employer negligence in terms of the worker's occupational safety and health (Hui-Nee, 2014). The construction sector rated at third place with a total of 67 cases (4.68%). This may result from the refined tools and equipment at construction sites which need proper handling, but which were operated by unqualified operators and thus caused injuries among them (Heap Yih Chong & Thuan Siang Low, 2014). Hotel and restaurants held the lowest number of cases in PD injury with 5 cases or 0.35%.

Table 12 shows the occupational accidents by sector resulting in death (fatality). The construction sector experiences more fatality cases when compared to other sectors. For NPD and PD, the highest number of accident cases occurred in the manufacturing sector throughout year 2007 to 2015. But, for fatal cases, the highest number was recorded in the construction sector with 652 number of cases or 36.08% for 2007 until 2015. As cited by Yakubu Danasabe Mohammed & Mohammad Bakri Ishak (2013), the root cause of occupational accidents at construction sites is the behaviour of the workers.

Meanwhile, manufacturing sector recorded the second highest number of fatalities with498 cases or 27.56%. The lowest number of fatalities was recorded in the hotel and restaurant industries with 3 (0.17%) cases, which follows the trend that the lowest number of accidents was also in the hotel and restaurant sector, as investigated by DOSH, with 233 cases from 2007 until 2015. From the overall number of accidents investigated by DOSH, it can be observed that the pattern of accidents reported varies from one sector to another, reflecting the difference types of hazards across sectors (Saad Mohd Said, Fatimah Said, & Zairihan Abdul Halim, 2012).

Table 12: Number of deaths caused by occupational accidents for the year 2007 until 2015

Year	Death (D)								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Manufacturing	63	79	63	59	45	40	58	45	46
Mining and Quarrying	9	9	3	1	7	7	5	15	4
Construction	95	73	71	66	51	67	69	72	88
Agriculture, Forestry, Logging and Fishery	10	43	44	30	41	38	33	42	31
Utility	2	20	23	11	5	5	7	0	6
Transport, Storage & Communication	3	8	18	14	11	22	8	15	22

Wholesale and Retail Trade	0	0	0	0	1	4	5	6	3
Hotel and Restaurant	0	1	0	0	2	0	0	0	0
Financial, Insurance, Real Estate & Business Services	4	4	1	1	7	4	0	4	14
Public Services and Statutory Bodies	3	2	1	3	6	4	0	5	0

(DOSH, 2008, 2009, 2010, 2011, 2014a, 2014b & 2015)

Based on statistics released by SOCSO, the number of industrial accidents recorded is higher than the reported cases by DOSH. Figure 5 below illustrates the number of industrial accidents reported to SOCSO and DOSH from 2007 until 2014. These accident statistics data includes all types of industrial injuries. On average, the number of accidents reported to SOCSO is ten times higher than the number of reported cases to DOSH. This leads to the question – could the number of industrial accidents actually be higher than the number of reported cases to DOSH and also SOCSO?, since the number of reported accident cases in SOCSO is only comprised of Malaysian workers and those who have already subscribed to SOCSO.

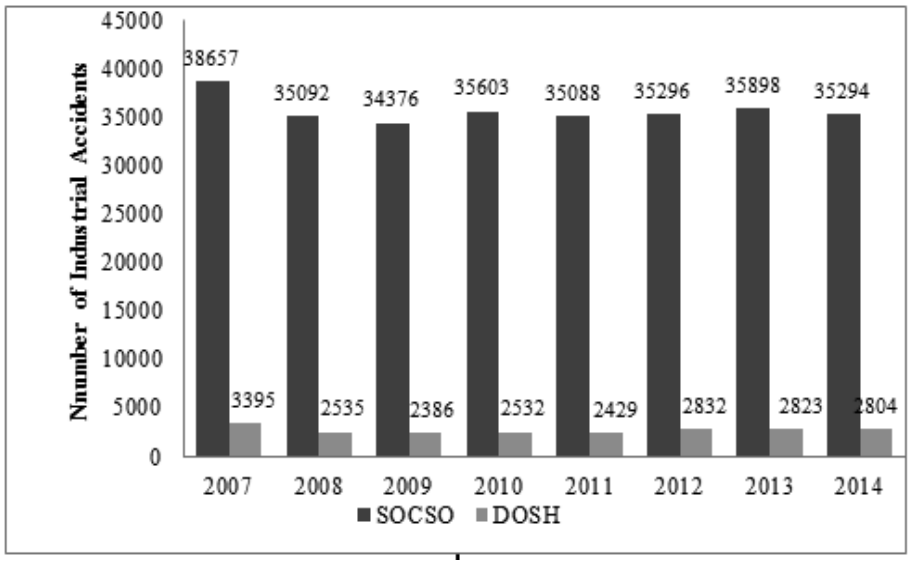

Figure 5: Number of industrial accidents reported to SOCSO and DOSH from the year 2007 until 2014 (SOCSO, 2009, 2010, 2011, 2012, 2013 & 2014) & (DOSH, 2011, 2014a, 2014b & 2015)

4.2 Occupational Accidents in Malaysian Construction Industry

Cases of construction accidents in Malaysia continue to register a high rate of industrial injuries and fatality. This scenario at construction sites gives us a picture that the Malaysian construction industry is one of the crucial sectors which need effective approaches in order to cut down the rate of recurrence in the future (Tan Chin Keng & Nadeera Abdul Razak, 2014).

Occupational injuries are preventable through control measures involving efforts on implementing safety and health practices at the workplace (Mohd Kamar, Lop, Mat Salleh, Mamter, & Suhaimi, 2014). Nevertheless, there are some factors contributing to occupational injuries in the construction sector. As cited by Noorul Huda Zakaria, Norudin Mansor, & Zalinawati Abdullah (2012), human factors are prone to cause occupational injuries and fatalities. Other factor include the nature of the job, mechanical failure, defective material, electronic failure, faulty design of equipment, and environmental conditions (Mohammad Muhshin Aziz Khan, Zaheed Ibne Halim, & Mohammad Iqbal, 2006).

Table 13 shows the number of accidents investigated by DOSH for the construction industry in Malaysia. The number of fatality accidents was the highest with 652 cases among NPD and PD accidents in the period 2007 to 2015, and is equivalent to 72.44 cases per year. This is also the highest compared to accidents that were investigated by DOSH for the period of 2007 until 2015 which represents 48.77% of the construction industry. Fatal accidents have been identified as frequently occurring accidents in the construction industry (Im *et al*., 2009). In addition, NPD and PD accidents that were investigated by DOSH accounted for46.23% (618 cases) and 5.01% (67 cases), respectively.

Table 13: Number of accidents investigated by DOSH construction industries

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Non-permanent Disabilities (NPD)	76	56	38	50	43	40	83	94	138
Permanent Disabilities (PD	10	3	6	2	5	12	12	6	11
Fatalities	95	73	71	66	51	67	69	72	88
TOTAL	181	132	115	118	99	119	164	172	237

(DOSH, 2008, 2009, 2010, 2011, 2014a, 2014b & 2015)

Based on Figure 6 below, the fatality cases in the construction industry from 2007 until 2011 marked a decrease in number from 95 cases to 51 cases. However, from 2012 onwards fatality cases recorded an increase in number from 67 cases to 88 cases. According to occupational statistics in Malaysia, the highest mortality rate is in the construction sector, where most of the fatalities are due to the high-altitude nature of the job, which contribute to fall from height accidents (CIDB, 2015).

These trends shared a similarity with NPD accidents which were marked a decrease followed by an increase in numbers throughout the period of 2007 until 2015. However, in 2009 NPD accidents recorded the lowest values with 38 cases. High accident rates in the construction industry indicate that this sector is a high-risk industry and employers need to provide a safe working environment for the workers (Mohd Misnan Sanders *et al*., 2013).

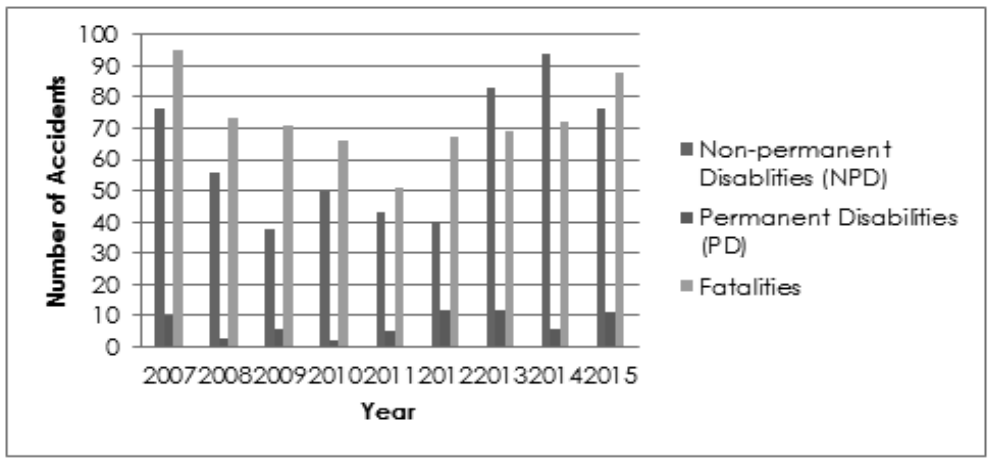

Figure 6: Number of accidents investigated by DOSH construction industry
(DOSH, 2008, 2009, 2010, 2011, 2014a, 2014b & 2015)

According to SOCSO from 2009 until 2014, out of the total of 211,555 industrial accidents reported, 31,347 were recorded in the construction industry. In 2010 alone, 6552 cases were reported to SOCSO, which was the highest number of cases. These include general construction workers (including civil engineers) and special trade contractors. Meanwhile, only 118 cases were investigated by DOSH in 2010. Table 14 shows the difference between the number of accidents reported in the construction industry by SOCSO and DOSH.

Table 14: Number of accidents reported in the construction industry

Year	Number of accidents reported in the construction industry (SOCSO)	Number of accidents investigated by DOSH construction industries (DOSH)
2009	4108	115
2010	6552	118
2011	5908	99
2012	5177	119
2013	4937	164
2014	4665	172

(SOCSO, 2009, 2010, 2011, 2012, 2013 & 2014) & (DOSH, 2011, 2014a, 2014b & 2015)

The huge gap between the SOCSO statistic reports and DOSH statistic reports suggests that the actual number of accidents in the construction sector is much higher still and is underreported. Underreporting cases for occupational accidents and diseases is a major challenge, especially for non-fatal accidents or less severe cases. Figure 7 below shows the difference in the number of reported cases to SOCSO and DOSH, the gap or margin between these two groups is 0.97 or 97.49%.

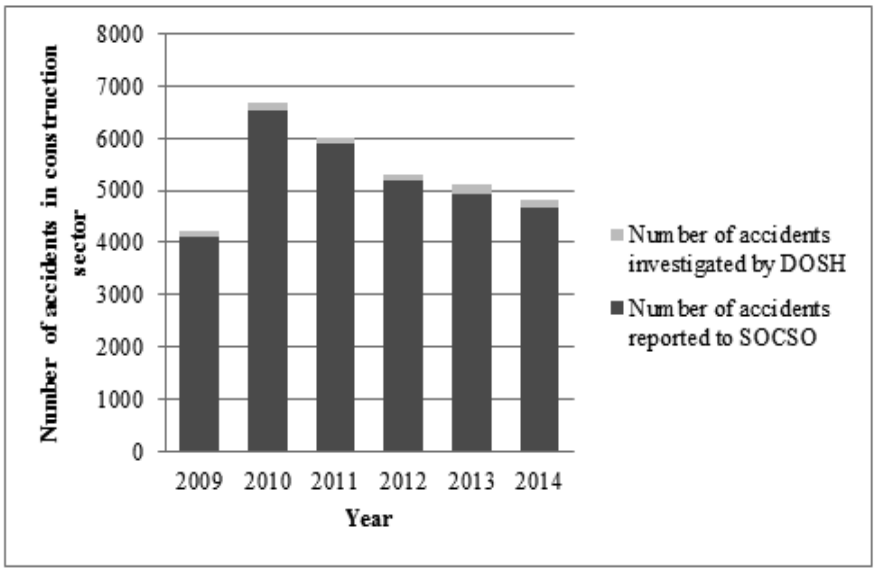

Figure 7: Number of accidents reported to SOCSO and DOSH
(SOCSO, 2009, 2010, 2011, 2012, 2013 & 2014) & (DOSH, 2011, 2014a, 2014b & 2015)

4.3 Underreporting of Accident Cases in the Malaysian Construction Sector

The enormous gap between the numbers of accidents reported to SOCSO and DOSH cause uncertainty on the exact number of accidents in Malaysian industries. Malaysia's Social Security Organization (SOCSO) was established for the purpose of claiming benefits when occupational injury occurs among Malaysian citizens who work in non-governmental jobs (Rooshida Merican Binti Abdul Rahim, 2010).

According to Adinegara Bin Lufti Abas, Abdul Razak Bin Mohd Said, Mohammed Azman Bin Aziz Mohammed, & Nalini Sathuakumar (2011), there is a tendency of underreporting because the injuries are self-reported, and may depend on employees' responsibilities as mild injuries may not be reported.

The accidents that went unreported could be higher because 80 per cent of Malaysian construction workers are foreigners who might have worked without or with expired permits (Abdul Rahim Abdul Hamid, Muhd Zaimi Abd Majid, & Bachan Sigh, 2008). Furthermore, SOCSO's figures only cover those workers who have already subscribed to SOCSO. Generally, the unsubscribing workers involve foreign workers (Occupational Safety and Health [OSH] Master Plan, 2015). It can be concluded that the data is incomplete since no statistical data is available among unregistered workers who are not registered for insurance claiming (Viego & Sagui, 2015).

The lack of official figures on the number of actual accidents occurring in the construction industry still remains, causing a major negative impact on the safety and welfare of the workers. This situation also leads to unsolved problems related to safety. Due to different ways to report the occurrences, there are many differences between each country in work-related accidents and disease statistics (ILO, 2014). Moreover, factual statistical data retrieved from the Department of Occupational Safety and Health (DOSH) cannot indicate the actual and absolute construction safety and health scenario in Malaysia (Heap Yih Chong & Thuan Siang Low, 2014).

5.0 Conclusion

The construction industry plays a very important role in national development due to its close relation with many other industries in Malaysia and its strength in generating national economic growth. The construction sector also provides job opportunities in professional and non-professional fields.

Contractors play an important role in determining good performance in the construction industry. In Malaysia, the number of registered contractors under grade G1 (with the financial ability to enter the tender not exceeding RM 200,000) is high. Meanwhile, the registered contractors with grades G6 and G7 (highest grade for entering tender) contain the lowest dormant contractors by percentage. In Malaysia, non-residential construction projects have the highest number and value of projects during the period of 2009 to 2013. During the same period, the most active construction in Malaysia was located in the states of Selangor, Johor and Kuala Lumpur.

Residence is a basic requirement for people, thus the housing construction industry is one of the important sectors in Malaysia. There is the highest number of housing development in large cities due to high demand. At present, high demands along with economic and demographic factors affect house prices. This in turn also makes the impression that it is increasingly difficult for people to own a home.

The risk of accidents in the construction industry is very high compared to many other industries in Malaysia. The highest type of accidents investigated by DOSH for the construction industry is fatal accidents. From 2007 until 2013, fatal accidents in the construction industry recorded overall the highest number among industries in Malaysia. Underreporting of the number of accidents in the construction sector is higher than investigated accident cases, which leads to the conclusion that the accidents in the construction industry should be given serious attention with ultimate aim of reducing losses of life, property and productivity.

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Safety Training and Safety Behaviour in The Malaysian SME

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Abstract: *Workplace accident is still prevalent in the Malaysian industry sector. Although statistics indicates that the number of accidents in the workplace is showing signs of decrease over the last five years, there is still room for improvements. According to report, a majority of the workplace accidents in Malaysia happened in Small and Medium Enterprise (SME). This shows that SME is still lagging behind in ensuring the safety of their workplace. This can disrupt their business activities as workplace accidents bring several negative effects. Therefore, this study explores the use of safety training to foster safety behaviour among employees. Surveys were distributed to employees working in SME, Northern Corridor of Economic Region (NCER). The data was analysed and results were presented. Suggestions to management in SME are made at the end of the paper.*

Keywords: *safety training, occupational safety and health, safety behaviour, SME.*

1.0 Introduction

Workplace accident is the focus of the Occupational Safety and Health (OSH) sphere in Malaysia. Every now and then, news of horrific workplace accidents are splashed across local news, fully exposing the hazards of the Malaysian workplaces. In year 2014, there are a total of 35,294 industrial accident reported cases. It is a small reductionfrom35,898 cases the year before. However, the cases on average does not vary much since 2007[1]. Importantly, it is estimated that for Malaysia,about 80 to 90 percent of the accidents reported to workmen compensation scheme (SOCSO) is from SMEs[2] and it is no different from the EU countries[3]. In addition, ninety-seven percent of business establishments in Malaysia are small and medium enterprises (SMEs). Specifically, these businesses are responsible for nearly 36% of the country's GDP, 65% of the country's employment, and nearly 18% of Malaysia's exports[4]. Thus, SME formed the backbone of Malaysia's economy.

This scenario is a common scenario for every country where SMEs formed the biggest employer for a country. More countries appreciate that employment and economic growth to a large extent depends on SMEs[5]. Therefore, many countries have launched programmes to support small enterprises. For instance, the EU gives high priority to improving the business conditions for[6] and the work environment in Commission of the European Communities SMEs[7]. Thus, the move to achieve a safe work environment for SMEs is timely and important to the sustainability of world economy.

Research Background

The high number of workplace accidents causes considerable losses to a company. The loss can be very damaging especially to Small and Medium Enterprises (SMEs) because of their limited financial capability and production capacity. However, with proper OSH management system, there will be a lot to be gain by the number of these firms[8] which is big in numbers not only for Malaysia but all nations around the world. Research has shown that 60% of companies that have a disruption lasting more than 9 days will go out of business[9]. Small businesses stand to suffer substantial losses because of poor OSH, but conversely can gain most if proper systems are in place[8].

One Finnish study (Ahonen, 1998) was able to show the economic benefits of achieving good OSH among SMEs[10]. The study surveyed 340 companies across different sectors and found specific benefits that could be achieved over the course of a year:

Table 1. Economic benefits of OSH activities

OSH activity	Economic benefit (estimated savings)		
	Low	High	Average
Reducing sickness absenteeism	MYR1358 (FIM*1,700)	MYR4,476 (FIM 5,600)	MYR1180 (FIM 2,665)
Musculoskeletal disorders			MYR995 (FIM 1,245)
Increased individual productivity	MYR2,957 (FIM 3,700)	MYR4,076 (FIM 5,100)	

*FIM = The Finnish MARKKA, and was the currency in use in Finland until 28.02.02 as legal tender.

As good OSH brings financial benefits, this is rarely assessed within SMEs. The negative impact of ill-health and accidents, on the other hand, is well documented, particularly in terms of the high costs involved when things go wrong. For example, in the EU15 in 2000, accidents cost €55 billion, 88% of which was due to lost working time[3], can lead to closure of a business due to the direct costs of dealing with the incident or the loss of contracts and/or customers and double the level of sickness absence.

A lot of the burden to ensure safe working falls on the shoulder of the employer. Even if the consequence of an unsafe act may cost employees his life which should be an ultimatum. Thus, a balancing act is greatly needed in managing safety at work to create responsible joint actions from both parties important in a working life.

This study aims to investigate the role of safety training in developing the safety behaviour of employees. It is the balancing act of acting upon the employers' responsibility to provide a mean to encourage safe work through training provision and the employees responsibility in translating it into a safe behaviour. Thus, it is aiming to answer the question of *"What is the relationship between safety training and safety behaviour?"*.

2.0 Literature Review

2.1 Safety behaviour

Griffin and Neal[11] defines safety behaviour as the performance of actual behaviour consisting of safety compliance and safety participation. Safety compliance includes all behaviours that directly lead to the safety of the workplace and it is regulated. On the other hand, safety participation describes activities that do not directly lead to workplace safety but supports the overall efforts to create a safer workplace.

Studies on behavioural safety conducted in the construction industry have come up with a wide range of activities that constitute safe behaviour. The proper use of scaffolding, good housekeeping, and the use of proper personal protective equipments are the common behavioural constructs used in studies conducted in the construction industry[12]. Those behaviours are considered as important to the industry as they can ensure the safety of worksites and employees working off sites. Other scholars also come up with their own safety behavioural measurements that fit the settings of their study. Specifically, Garavan and O'Brien[13] study on a safety behaviour checklist that consists among it, correct responses in hazardous situation, communication of unsafe work conditions, proper use of equipments, break of safety rules, engage in preventive safety behaviour, attention to rules or procedures, and good housekeeping practice. Hofmann and Stetzer[14] also suggested several categories of unsafe behaviours such as improper tool use, improper storage of tools, failure to wear personal protective equipments and risky work strategies.

As the safety behaviour constructs mentioned above may not be suitable for studies in a more general workplace setting, this study will use safety behaviour measures developed by Griffin and Neal [11]which can be generalized across a wide variety of workplace settings. Examples include following safety procedures while working and using the right protective equipments if applicable. These behaviours ensure the safety of the employees by decreasing the chances of accidents. On the other hand, safety participation is a host of activities that employees undertake that may not directly lead to workplace safety but they contribute voluntarily towards creating a safer workplace. Examples include volunteering in safety activities and participating in safety meetings. Activities such as participating in safety meetings contribute to the creation of a safer workplace because employees can voice their opinion and suggestions on how to improve workplace safety.

Past researches have found several determinants to safety behaviour such as safety training, supervision, employee participation, and safety rules that affect safety behaviour of employees[15]. The effects of safety training have been study in high-risk industries such as mining and construction. Alacchi and Todradze[16] stated that safety training given to mine workers can increase their awareness on safety problems in their work place. Safety training must be given to all levels of employees in the mine to solve the problem. Workers who work inside the mine must be trained because they are the ones who involved directly in accidents. Thus, changing their behaviour through safety training can reduce the number of accidents in the mines. In addition, employees in the management level must be given safety training particularly in the area of accident theory to enable them to analyse the causes of accidents. It was proven to be very useful for management in identifying the safety problems in the mine to take corrective measures. Fiedler, Bell, Chemers&Patrick[17] also found that safety training given to management personnel working in mines and organisational development efforts (such as team building and problem- solving meetings) aimed at other mining workers in the organisation managed to decrease the incident of safety violations, increase productivity in the mines and improved overall safety records in the mines. Similarly, safety training from the lower level of employees to the management level was emphasised in the construction industry[18]. Majority of managers interviewed in the study indicated that safety training is a good safety practice taken by the organisation to improve construction sites' safety. Employees

who attended safety training also reported of increased awareness of hazards in the workplace and overall safety issues. The findings in these two high-risk industries highlighted the fact that safety training is important in both the management level and the rank-and-file workers because the safety of the workplace is dependent on the roles played by both parties. Safety training can improve the abilities of both parties to contribute to the safety in their workplace. Moreover, in high-risk industries, a slight mistake by either the rank-and-file employees of the management can lead to disastrous accidents. Therefore, an effective safety training program aimed at both parties is necessary to avoid accidents.

2.2 Safety training

Safety training is a type of training that is aimed at equipping employee with the necessary capability to behave safely during work and avoid accidents. The capability can be in the form of awareness towards safety issues in the workplace[17], knowledge about safety[19], and improve risk perception[20]. It helps employees to cultivate safety behaviours and contribute towards the safety of the workplace. In highly-industrialised country such as the United States, safety training started out informally, often in the form of on-the-job training where a master teaches his apprentice the necessary skills to get the job done unhurt[21]. When the Occupational Safety and Health Administration (OSHA) was established in the 1970s, safety training became formal and is enforced through legislation and regulation to ensure employers provide safety training for their employees. This heralded a 'modern' era of safety training and the trend is spread across the world and continues until today. Since then, safety training has become an important part in the field of OSH today.

Years of development and research in the area of training particularly safety training has resulted a vast accumulation of knowledge regarding it in the Occupational Safety and Health (OSH) literature. It is one of the most important and widely-used interventions in the field of OSH due to its effectiveness in helping to foster safety behaviour and decreasing overall accident rate in the workplace. For example, Fiedler, Bell, Chemers and Patrick [17]found that safety training is effective in increasing safe working condition and productivity. Besides,Cooper[22] also advocates safety training as it helps to prevent workplace accidents and lower risk. In addition, Alacchi and Todradze[16]proposed that continuous safety training to be given at all levels of employees as a long term exercise because training takes time to be effective as learning is a progressive process.

Past studies have established the relationship between safety training and safety behaviour as well as OSH as a whole. An exploratory study done by Hilyer, Leviton, Overman and Mukherjee[23] on union-initiated safety training indicated that 84% of the employees reported that they can identify and recognize hazardous chemicals easier after attending the safety training. In addition, 73% of the employees indicated that they talk to other workers about health and safety more frequently after going for the safety training. Although there is no cause-and-effect relationship established in this study, but there is an indication that safety training can have a positive effect on the attitude and behaviour of employees.

In another study done by Komaki, Heinzman and Lawson[24] in a vehicle maintenance division, it is found that safety training and feedback is effective in training the employees to work safely. The employees were subjected to safety training in which they were presented with slide shows of other workers performing their tasks. They were then asked to identify unsafe acts performed by the workers and suggest safety rules to curb those unsafe acts. The employees who undergone the training recorded a 9% increase in safety performance. When feedback was given over their performance, an increase of 26% in safety performance was recorded. The result indicates that both safety training and feedback are important component in improving the safety practices of employees.

In addition, a study conducted by Reber and Wallinin[25] a manufacturing plant confirmed the positive effect of safety training and feedback on employees' safety behaviour. Employees were subjected to safety training whereby they view slides of other workers performing unsafe acts during work and were asked to point out the unsafe acts. Observations were made at pre and post-training to identify the safe and unsafe behaviours of employees. Results from the observation showed that the safety performance of employees increased to 70.85% after safety training as compared to 62.2% before the training. Furthermore, after feedback was given, the safety performance increased significantly to 95.39%. This study confirms the results obtained by Komaki, Heinzman and Lawson [24]. Therefore, safety training is effective in improving safety behaviour of employees and feedback maximizes the effect of safety training.

As a summary, safety training is an effective intervention to cultivate safety behaviours. The safety awareness and knowledge provided by trainings are invaluable skills that employee could have in helping them to work and behave in a safe manner. Thus, it is hypothesised that:

H1: Safety training has a positive significant relationship with safety compliance.

H2: Safety training has a positive significant relationship with safety participation.

3.0 Methodology

3.1 Variables and measurements

Safety behaviour. The measurement for safety behaviour is adopted from Griffin and Neal [11]. Safety behaviouris operationalisedas having 2 dimensions namely safety compliance and safety participation. Safety compliance measures the behaviour of employees in relation to their own safety. An example of the item is: "I use the correct safety procedures for carrying out my job". Safety participation measures the behaviour of employees that does not directly leads to their own safety but can contribute to the creation of a safer workplace. An example of the item is: "I voluntarily carry out tasks or activities that would help to improve workplace safety". All the items are measure by a response scale of 7-Point Likert scale (1= *strongly disagree*, 7= *strongly agree*).

Safety training. Safety training is measured using items adapted from Vredenburghas[26] well as Worsfold and Griffith[27]. Items adapted from Vredenburgh[26] were used in the hospital setting to measure the safety training given to hospital employees to help them avoid common injuries in the industry such as strains and sprains, needle punctures, communicable diseases, and burns. Items from Worsfold and Griffith[27] were used in the retail and catering industry to measure the safety and food hygiene training given to various level of employees namely the junior staff, senior staff and supervisor. They were modified so that they can be generalised across different industries as needed by the current study. For examples, wordings such as 'food safety' and 'food hygiene' that are specific to the food industry were removed. The items measure whether safety trainings such as on-the-job training and training that enables employees to identify hazards are given to employees. Example of the items include: "On-the job training is given to all new starters". A response scale of 7-Point Likert scale (1= *strongly disagree*, 7= *strongly agree*) follows each items.

3.2 Population and Sample

This study aims to measure employee's safety behaviour and is focused in the manufacturing sector of Northern Corridor of Economic Region (NCER) - an economy development area gazetted by the Malaysian government to be further developed. NCER covers the state of Penang, Perak, Perlis and the northern area of Perak. Thus, the sampling frame consists of all employees working in SME in the manufacturing sector operating in all four states of NCER. A company listing was used to select the intended respondents because a complete list of employees working in SMEs in NCER could not be obtained.

Listing of SMEs in NCER was obtained from SMECorp (formerly known as SMIDEC) through a formal request. The listing was then updated and cross-checked with several other SME directories such as SMEInfo, SMI Business Directory and directory provided by SME Bank to ensure that the list is updated. Through a random check of the SMECorp list made prior to data collection, many of the companies are no longer SMEs or have ceased to operate. Thus, a cross-check was done to ensure that an updated and more complete list is available to the researcher before proceeding with data collection.

In determining the appropriate number of sample size without a definite information of the population, this study looks at the requirement for factor analysis as a guidance. In order to conduct factor analysis, a minimum of five subjects per item is adequate based on the requirement for factor analysis[28]. The variable with the most items is safety behaviour with a total of 12 items. As such, 60 subjects are needed for the current study[29]. Therefore, a sample size of 150 is decided as appropriate for the current study . In addition, Smith and Davis[30] argued that surveys using mail generally have a response rate of 25 percent to 30 percent. Therefore, the author decided to send out a total of 800 questionnaires to employees working in SMEs in the manufacturing sector in NCER to increase response rate.

However, before the questionnaires were sent out, an appropriate ratio between small enterprises and medium enterprises has to be established. According to the Census of Establishment and Enterprises 2005[31], there is a total of 2216 small enterprises and 314 medium enterprises in the manufacturing sector in NCER. In order to obtain a proportionate number of the sample, a ratio of 7:1 between small enterprises and medium enterprises has been established.

The listing of the companies was divided into two main categories- small enterprise and medium enterprise based on the number of employees with micro enterprise excluded. SMEs in each category were numbered and a random number generating software was used to sample the SMEs from each category based on the ratio set above. A total of 212 small enterprises and 30 medium enterprises were selected from this exercise.

Human Resources Managers of the chosen companies were contacted for permission to distribute the questionnaires to their employees. The Human Resources Managers were asked to distribute the questionnaires to their employees at their own discretion. In total, 800 sets of questionnaire were sent to employees working in the SMEs selected earlier. Using the small enterprises to medium enterprises earlier ratio, 700 questionnaires are sent to the small enterprises while 100 questionnaires are sent to the medium enterprises. The number of questionnaires distributed to each company is based on negotiation with the Human Resources Managers who agreed to participate in this study.

3.3 Data Collection Procedure

Questionnaires were mailed to respondents through the human resource managers. SMEs were selected using a random number generator using the computer and the researcher contacted the human resources manager of each identified company. The researcher informed the managers about the purpose of the research in seeking the manager's cooperation to distribute the questionnaire to employees in his or her company. SMEs which declined to participate after much persuasion effort is replaced by another SMEs using similar selection method stated earlier.

A cover letter is then sent to the managers who agreed to participate. The content of the cover letter gives the necessary details regarding the purpose of the study as well as the benefits of this study to SMEs. Detailed instruction on how to administer the questionnaires is explained. Specifically, the researcher informed the Human Resource managers to distribute the questionnaires to employees in the company randomly. Two measures are suggested to the managers to help maintain randomness. Firstly, the managers are suggested to randomly pick the employees that are going to receive the questionnaire by picking them from a number list that corresponds with the name list of all their employees in their company. Random number generating software readily available online is also suggested as an alternative. However, due to the fact that the researcher has no control over the actions of HR Managers who participated in this study, randomness is not guaranteed.

The researcher also sends a postcard with handwritten messages to the HR managers as a sign of gratitude and to improve the response rate. The managers are also informed to expect the arrival of the questionnaires in the following week. Finally, the researcher promises to share the results of the study. The questionnaires are mailed to the HR managers with self-addressed stamped envelopes for the convenient of the respondents to return the completed questionnaires. Five days after mailing the sets of questionnaires, the researcher makes a follow up call to each of the HR Manager to check whether they had received the questionnaires. No follow-up calls were made as 160 sets of completed questionnaires were returned within a month. The 160 sets of completed questionnaire were adequate to perform the statistical analysis required for this study.

4.0 Results

One hundred and sixty out of 800 sets of questionnaire were returned, representing a 20% response rate. Based on the results obtained, the participants of this study are primary male with a rate of 63.1% compared to female at 36.9%. Majority of the respondents (52.5%) falls under the 31 to 40 years of age group. This follow by 21 to 30 years at 32.5%, 41 to 50 years at 10.6% and the smallest group is those above 50 at 4.4%. In term of ethnicity, a majority of the respondents are Chinese at 58.8%, followed by Malay at 31.3%, Indian at 7.5% and other ethnic group at 2.5%.

In addition, the results also show that 30% of the respondents are diploma holder while 29.4% of them only have secondary qualification (SPM/MCE). Almost 20%of the respondents have bachelor degree or higher qualification, followed by certificate holders at 18.1%. The smallest group is those having lower secondary qualification such as PMR/SRP/LCE report at 3.1%.

In term of position held in their respective organisation, there are 72 employees or 45.1% holding the technical position. This is followed by 47 employees or 29.3% holding a supervisory position. Besides that, there are 30 employees or 18.8% holding executive positions. Those holding managerial positions made up the fourth largest group with 9 employees or 5.6%. The smallest group is the 'Other' category with 2 employees or 1.2%. In addition, 55.6% of the companies are categorised as small enterprise with 5 to50 employees while 44.4% are categorised as medium enterprise with 51 to 150 employees.

Multiple regression analysis was used to test the hypotheses in this study. It is deemed as an appropriate analysis as all assumptions were fulfilled before analysing using multiple regression. Safety training were regressed against the two dimensions of safety behaviour namely safety compliance and safety participation. From the results, safety training was found to have a positive significant relationship with safety compliance ($\beta = 0.42$, $p \leq 0.01$) as well as safety participation ($\beta = 0.5$, $p \leq 0.01$). Therefore, hypotheses H1 and H2 are supported. The result of the analysis is summarisedin Table 2

Table 2: Summary of the Multiple Regression Results for Safety Training and Safety Behaviour

Variable	Safety Compliance	Safety Participation
	β	β
Safety Training	.42***	.50***
Overall F	34.18***	67.81***
R^2	.18	.30

Note. N = 160. Entries are standardized regression coefficients.*** $p \leq .01$

5.0 Discussion and Conclusion

Consistent with study done by Komaki, Heinzman and Lawson[24] and Reber and Wallin[25], safety training was found to lead to an improvement in employees' safety behaviour. Safety training provided by the employers can improve the safety performance of employees. This will in turn decrease industrial accident rate because when employee behave safely while performing their tasks, the chances of human error can be minimized.

Even for SMEs, safety training proves to be important in ensuring the achievement of safety behaviour among the employees. Nonetheless, this study did not examine the structure and the delivery of the training and thus future studies may want to investigate in depth of what structure of training and the type of approach used would be most effective. As participants are adult learners and practitioners with rich experience, training may be able to structure methods that could further enhance the effect of safe work for the company.

As a conclusion, safety training can bring a lot of benefits to employees in SMEs and improve their safety performance. However, more studies can be done on safety training to better understand its effect on employees. The content of safety training, methods of delivering it, and the length of safety training are among the dimensions that future researchers can explore. This will hopefully enhance the positive effects of safety training have on employees.

Acknowledgement

An acknowledgement to University-RUI Grant 1001/PMGT/816052 which supported this research. A special thanks to the Institute of Postgraduate Study, UniversitiSains Malaysia for providing some financial assistance to carry out this study.

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Relationship Between Safety Climate Perception and Safety and Health Management System with Occupational Accident at Small Medium Industries in Selangor

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Abstract: *The frequency of occupational accident in small medium industries decreased from 2008 in general, but fluctuated each year, which shows that improvement is needed in handling safety and health of the employees. It is believed that safety climate perception and occupational safety health management system (OSHMS) influence occupational accident in an organization. A safety audit checklist and self-administered questionnaire was distributed to the involved small medium industries. The findings show that safety climate perception was high in small medium industries while OSHMS show low compliance. Findings also showed that there were significant relationships between safety climate perception and OSHMS with occupational accident in the organizations ($p<0.05$).*

Keywords: *safety climate perception, job satisfaction, occupational accident, small medium industries.*

1.0 Introduction

Manufacturing sector of small and medium industry (SMI) in Malaysia has rapidly expanded consistently due to Malaysian 2020 vision to become an industrialized country. Despite the contribution of SMIs to Malaysian economy, employees in this sector are suffering high cases of fatality annually due to workplace accidents and work related health hazards. In 2011, there were 35 088 (58.58%) of industrial accidents reported and published by the Social Security Organization (SOCSO) of Malaysia [1].The scenario that concerns responsible bodies is that 80% of reported industrial accidents were contributed by SMI [1]. It can be concluded that there is unquestionable evidence that SMI has high risk for occupational accident compared to larger industries.

Statistics for occupational accident cases in Malaysian manufacturing sector fluctuated between 2008 and 2013 as shown in Figure 1. The frequency of occupational accident decreased from 2008 in general, but fluctuated each year, which shows that improvement is needed in handling safety and health management and employees' wellbeing in Malaysian manufacturing sector [2].

SMIs in most developing countries have a number of common similarities and limitations. Most SMIs tend to view occupational safety and health as having the lowest priority in an operation and have never treated it as a crucial part of the overall management [3]. Typically, occupational accident is caused by unsafe condition and unsafe behavior [4].

Rather than conventional method, which measures safety using retrospective data (occupational accident), leading indicators such as safety audit and safety climate measurement are more proactive and predictive of occupational accident. Safety audit and safety climate also helps to identify appropriate control measures before a system fails [5]. In this context, occupational safety and health management and safety climate perception are factors that may affect the safety behavior of an employee, either directly or indirectly.

Safety management and organization impact the safety performance of a company [6]. Safety management of an organization can directly or indirectly affect safety performance and increases the rate of occupational accidents [7].

Safety climate perception is also seen as a crucial predictor for individual behavior in the workplace [8]. Safety climate is an organization construct believed to affect the safety behavior of employees at individual, group and organizational levels [9]. Safety climate also anticipates safety related outcome [10]. Safety climate is a measurement of safety behavior of employees while working. Better safety climate indicates lower accident rate in an organization [11].

However, only few safety climate studies were conducted in Malaysia, especially in the manufacturing industry [12]. Similarly, Malaysian Department of Occupational Safety and Health also reported very limited research on safety climate and safety management conducted in Asian countries [13]. The aim of this study was to investigate two factors, which were occupational safety health management and safety climate perception believed to influence the occurrence of occupational accidents at workplace.

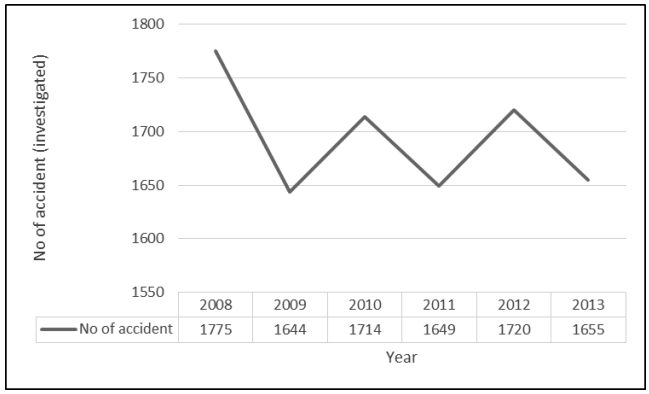

Figure 1 Workplace accidents in the manufacturing sector from 2008 to 2013.

2.0 Methodology

This study used a cross-sectional study design focusing on SMIs population in the places of interest in Selangor. The data in this study were gathered at a single point in time. This study was conducted at selected small and medium manufacturing industries located in Selangor. Selangor has the highest distribution of small and medium manufacturing industries with 8,314 companies representing 22% of the distribution throughout Malaysia as shown at Figure 2 [14].

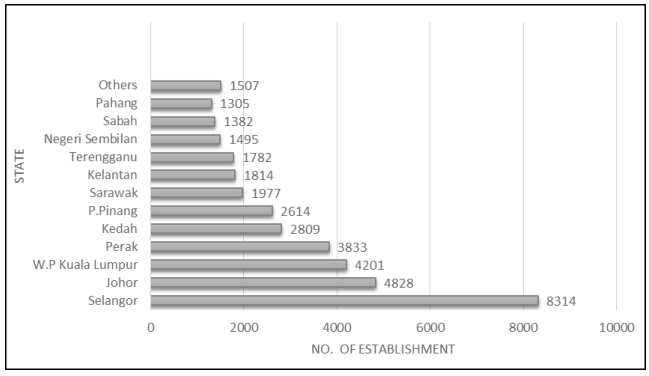

Figure 2 Distribution of SMIs manufacturing sector by state, 2010

The samples for this study were employees who work in the production department and are involved with machinery. The respondents were given a set of questionnaire to measure the safety climate perception and occupational accident at the individual level. A safety audit checklist was used to measure the occupational safety and health compliance at the management level.

Safety audit checklist used in this study was adapted from Malaysian Society of Occupational Safety and Health [15]. The Occupational Safety and Health Management System comprises of five elements as shown in Table 1.

Table 1 I Elements and Measures in Occupational Safety and Health Management System Audit Checklist

Element	Measure	Weightage (%)
A	Policy	10
B	Organizing	15
C	Planning and implementation	60
D	Evaluation	10
E	Action for improvement	5
	Total	100

Nordic occupational safety climate questionnaire was used in this study to measure the safety climate perception of the workers in the selected factories [16]. The component of this questionnaire is shown in Table 2. Higher score for safety climate perception indicates better safety climate at the factories.

Table 2 Dimensions, items and score of safety climate measurement

No.	Dimensions	No. of Items	Score
1	Management safety priority	4	24
2	Management safety empowerment	4	24
3	Management safety justice	3	18
4	Workers' safety commitment	7	42
5	Safety communication	4	24
6	Workers' trust in efficiency of safety system	4	24
	Grand total	26	156

Self-reported occupational accident history was the most suitable method to get data on the frequency of accident in the factories. This method is the most appropriate since there was no access to formal accident data given on factories, especially for SMIs. Occupational accident items in this study were constructed by the researcher, and some of the questions were based on Occupational Safety and Health Council of China [17]. Four items were developed to measure occupational accident of the factories involved in this study. The questions in this section contained open-ended questions (Yes and No) and Likert scale item ranging from 0 to 6 (0 = never to 6 = five times or more). The subscales in the measurement of occupational accident included frequency of occupational injuries, type of injuries and day off due to occupational injuries in the workplace.

From the pre-testing stage, the reliability of the questionnaires was determined through the percentage of questionnaire validity in the research study. Table 3 shows the reliability value for the tested questionnaires.

Table 3 Questionnaire Reliability Test

Questionnaire Reliability Test Items	Number of Items	Cronbach's Alpha
Safety climate perception measurement	26	**0.959**

3.0 Results and Discussion

The OSHMS level was assessed for selected small medium industries. The results describe that the highest compliance with occupational safety and health was 89% and the lowest was as low as 3%. The result describes that most of the factories involved in this study were classified as having low compliance with the elements of occupational safety and health management system. It shows that the level of safety awareness among small medium manufacturing industry was inadequate and far behind the large manufacturing industries. Even though the Occupational Safety

and Health Act 1994 was introduced, the small and medium industries employers still do not comply with some of the requirements in the safety law. The highest mean score was for planning and implementing safety element in occupational safety and health management. Planning and implementation include system objectives, system planning and implementation and hazard prevention. Some employers provide safety training to their employees in order to protect from hazard at workplace. The effectiveness of safety training helps to reduce occupational accidents and injuries [18]. The lowest mean score for occupational safety health management system element was the action for improvement. Actions for improvement include preventive and corrective actions and continual improvement. Most employers did not establish and maintain preventive and corrective actions in the workplace. Employers identified non-conformity without analyzing the root-causes with relevant occupational safety health regulations. Proper arrangement and documentation for corrective and preventive actions in the workplace is poor. Most employers cannot maintain continual safety improvement for the safety objectives established.

Most respondents showed high score of safety climate perception in the workplace, which showed that they have been exposed to the basics of safety and health in the workplace, even if the occupational safety health management system is not implemented in the organization. The highest overall mean score was the workers' safety commitment dimension with a mean of 26.04 ±5.81, which corresponded to the commitment towards workers' safety. It shows that SMIs employees emphasized more on safety commitment in the workplace. Employees were concerned about their safety while performing a job. This finding is similar with a previous study who found that the highest mean score for employees' safety commitment in small medium manufacturers [19]. The lowest mean was 12.25 ±2.54, which corresponded to the safety management priority. This finding is similar with Bahari [12], who reported the least score on management safety priority in manufacturing plants in Malaysia. This finding showed that the management still gives less attention to the importance of safety priority in the workplace. Certain employers allow employees to neglect safety in order to achieve the productivity target and to increase the income level of the company.

Safety climate perception score and occupational accident frequency based on compliance levels of occupational safety health management system result showed at Table 4. The means of safety climate perception and occupational accident were significantly different with the level of occupational safety and health management system. This finding is in tune with other researcher who conducted a study on 131 OHSAS 18001-certified companies in Spain and found that occupational safety and health management level was associated with safety climate perception of employees [20]. High compliance with occupational safety and health management showed high score of safety climate perception than low compliance with occupational safety and health management. This finding is due to the fact that better safety climate perception increases occupational safety health management compliance in an organization. It also believed that occupational safety health management is associated with safety climate perception of the employees. A previous study is also consistent with this finding when they found that the application of occupational safety health management system reduced the occupational accident within an organization [21]. It was also supported by Arocena & Nunez [22], who studied 193 Spanish manufacturing SMIs and showed that occupational safety and health management system significantly affected occupational injury. They found that high compliance with occupational safety and health management system showed lower accident rate (0.060, ±SD 0.049) than lower compliance (0.117, ±SD 0.071). They also revealed that there was 59% difference in the accident rate between factories with high compliance and low compliance, which could be explained by the implementation of occupational safety and health management system. These finding is due to the fact that occupational safety health management system is associated with occupational accident frequency at the workplace. Occupational safety health management system is the effective approach to prevent and minimize occupational accident occurrence at workplace. Moreover, there is no study showed no association between occupational safety health management system and occupational accident at workplace.

Table 4 Safety climate perception score and occupational accident frequency based on compliance levels of occupational safety health management system

Variable	Mean (SD) of OSHMS		*t* statistic (df)	*p* value[a]
	Low	High		
Safety climate perception	103.27 (16.44)	126.32 (13.94)	-11.29 (181)	**<0.001*** **
Occupational accident	1.00 (1.19)	0.19 (0.53)	7.21 (232)	**<0.001*** **

[a]Independent t test

***p<0.001

The coefficient of correlation for safety climate perception was 0.217, which was the highest among all variables. This shows that 22% of variation in occupational accident could be explained by safety climate perception. Safety climate perception and occupational safety health management showed significant relationships with occupational accident ($p<0.05$) as shown at Table 5. Safety climate perception was negatively correlated with occupational accident. Results from this study correspond to the previous research that emphasized the fact that occupational accident is contributed by the prevailing safety climate perception in the workplace [9, 23]. It is possible that safety climate perception has contribution towards occupational accident occurrence in the workplace. In addition, it is found that dimensions of safety climate perception were negatively correlated with accident rate over a period of time [24]. Organizations with efficient and strong safety climate perception among their employees have lower accidents and injuries rate due to efficient management commitment on safety-related matters [25]. This finding concerned with the importance of safety climate in order to improve organizational safety performances.

Occupational safety and health management system had negative significant correlation with occupational accident occurrence. This finding is in agreement with other study which found a significant relationship between safety management commitment and self-reported accident frequency, suggesting that high compliance with occupational safety and health management scores have favorable effects on accident proportion in the factory [26]. Other study also found that the safety management system is one of the predictive measures of lower accident cases and one of the preventive measures for accident in the workplace [6]. It is because occupational safety and health management may be helpful in encouraging the organizational safety climate that highlights the importance of safety and job satisfaction and thus, encourages safe work practices, and gives necessary information on handling a job correctly. This results in decreased rate of accidents in the workplace.

Table 5 Relationship between safety climate perception and OSHMS, occupational accident

Variables	*b* (95% CI)	*t* statistics	*p* value[a]	r^2
Safety climate perception	-0.027 (-0.033,-0.020)	-8.070	**<0.001*** **	0.217
OSHMS	-0.015 (-0.020,-0.011)	-7.014	**<0.001*** **	0.173

[a]Simple linear regression

***p <0.001

4.0 Conclusion

In this study, the findings indicate that there were significant relationships between safety climate perception and occupational safety and health management with occupational accidents in SMIs in Selangor. The compliance with occupational safety and health management among SMIs in Selangor was considered as low since five of seven organizations showed low compliance. Meanwhile safety climate level among SMIs employees were considered high since the average score was more than half of the total score. The findings also showed that high compliance with occupational safety health management increased safety climate perception and decreased occupational accident.

Acknowledgement

The authors fully acknowledged Universiti Putra Malaysia and Universiti Teknologi MARA for the expertise in advised and supervised for this research.

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A Review on the Guidelines Related to Risk Assessment for Confined Space

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Abstract: *The aim of this paper is to identify, review and carry out comparison to seven guidelines where the main focus is on its risk assessment elements related to confined space activities. This is due to lack of the specific approach of the Legislation for confined space such as entry procedure requirements, risk assessment method, existing practice of risk assessment is too general and additional references are required for conducting risk assessment which would lead to poor response from industries. The selected guidelines will be summarized on its requirements, followed by a review of each guideline and finally the comparison of Legislations will be carried out. The results from the study would be used as a contribution factor to promote an ideal method in developing an effective risk assessment tools for working safely in confined space. Furthermore, several literatures which have been referred could give additional input for developing the risk assessment tools.*

Keywords: *Guidelines Requirements, Risk Assessment, Confined Space, Guidelines Comparison.*

1.0 Introduction

Every task to be carried out in an organization required specific safety and health guidelines to ensure all works to be done is under control for the sake of safety, health and welfare of workers. This is including working in confined space which required special attention prior work started such as application for Permit to Work system and Atmospheric Gas Testing. On top of that the management participation is also part of the requirements to ensure the entrant is safe during occupancy by ensuring the procedures are being adhered according to the established safe work system. By definition, confined space is an enclosed or partially enclosed space that is at atmospheric pressure during occupancy and not intended or designed primarily as a place of work and it is liable at any time to have an atmosphere which contains potentially harmful levels of contaminants, have an oxygen deficiency or excess, cause engulfment and have restricted means for entry and exit (Standards Australia, 2001. Safe Working in Confined Space). Examples of confined spaces are storage tanks, tankers, boilers, silos, pipes, sewers, tunnels, shafts and ducts (Standards Australia, 2001. Safe Working in Confined Space). The definition of risk assessment can be described as a process of evaluating the risks to safety and health arising from hazards at work (Guidelines for Hazard Identification, Risk Assessment and Risk Control, Ministry of Human Resource, Malaysia).

The review of seven Guidelines which to be carried out is from United Kingdom, United States of America and Malaysia. The Guidelines are UK Ministry of Defense Health and Safety Handbook: Safe Working in Confined Space UK, HSE UK-Confined Space: A brief Guide to Working Safely, British Compressed Gas Association: The Application of the Confined Spaces Regulations to the Drinks Dispense Industry, US ASHRAE Guideline: Guideline for the Risk Management of Public Health and Safety in Buildings, Malaysia Industrial Code Of Practice 2010: Safe Working in Confined Space, Malaysia Guidelines for Hazard Identification, Risk Assessment and Risk Control and Malaysia Guidelines on Occupational Safety and Health Management System. The selection of Guidelines are observed through the main elements presented is able to assist in developing an effective risk assessment tools for confined space. Besides that, the present issues in confined space risk assessment required further enhancement on its risk assessment tools due to lack of specific approach of confined space works such as entry procedure requirements, risk assessment method, existing practice of risk assessment is too general and additional references are required for conducting risk assessment which would lead to poor response from industries. For that instance, the aim of this paper is to identify, review and carry out comparison to seven Guidelines where the main focus is on its risk assessment elements related to confined space activities and the outcomes of the study will be used as a contribution for developing an effective risk assessment tools for working safely in confined space.

Moreover, several literatures are being referred with regards to the implementation of Standards, risk assessment and confined space safety. In designing an effective risk assessment tools for confined space entries, Vienney *et al*., (2015) stated that, the Guidelines being used plays an important input during tools development process. As an examples, when comes to the steps of risk estimation process, it would involve with a various type of conditions such as usage of machines, building construction and oil & gas operation. For building construction risk assessment, Aneziris *et al*., (2011) has proposed a risk assessment base on the Occupational Risk Model for quantifying occupational risk. In oil & gas industries, Aneziris *et al*., (2012) has presented an integrated risk assessment framework for Liquefied Natural Gas terminals. The above literature of risk assessment is to demonstrate the importance of industrial Guidelines as a reference documents during risk estimating process, mainly for works related to confined space entries.

The Guidelines being selected is focus on the risk assessment concept where the entire content will be reviewed in order to ascertain its relevant input towards risk assessment for confined space. The list of Guidelines in Table 1 will illustrate its objectives & application, similarity, difference and significance of its content.

According to summary of content listed in Table 1, the Guidelines requirements will be identified and followed by a review of each Guidelines with respect to risk assessment elements of confined space. The review of Guidelines is according to the current industrial practices and experiences and it will provide an overall conclusion on its suitability and practicability in enhancing health and safety standard for confined space works.

Table 1 Summary of Seven Guidelines

GUIDELINE	OBJECTIVE & APPLICATION	SIMILARITY			DIFFERENCE	SIGNIFICANCE
MoD UK (Ministry of Defense, United Kingdom)	Applied for all MoD UK facilities either in United Kingdom or abroad. Guidelines is not applied to shipboard activities, mining operations, diving operations, confined space containing petroleum products and any tasks involving works at height.	Introduction	None	None	Roles and duties, general arrangements, management arrangements, confined space entry procedure, training, health requirements and example of forms & signage.	Confined space entry procedure
HSE UK (Health and Safety Executive, United Kingdom)	The Guidelines is purposely for industries in United Kingdom. It also use in order to comply to the Confined Space Regulations 1997.	Introduction	None	None	Type of confined space, dangers of confined space, related laws, avoid entering confined space, safe system of works, emergency procedures and capability of rescuers.	Safe system of works, emergency procedures
BCGA UK (British Compressed Gas Association, United Kingdom)	To establish a common standard for working in confined space in drinks dispense industry and apply to all business involve in the use of drink dispense gases as well as for gas suppliers.	Introduction	Scope	None	Key properties of gases used for drinks dispense, related confined space regulation, assessment of risk, actions resulting from assessment, competence & training and personal protective equipment.	Assessment of risk, actions resulting from assessment
ASHRAE US (American Society of Heating, Refrigerating and Air-conditioning Engineer, United States)	To provide a guidance for the practical evaluation, design and implementation of measures to reduce multiple risk in new and existing buildings. To address the aspect of building performance that affect occupant health and safety.	None	Scope	Purpose, definition	Risk management approach, design for new and existing facilities and operation & maintenance of buildings.	Risk management approach, examples method in assessing risk.

HIRARC MY (Hazard Identification, Risk Assessment, Risk Control, Malaysia)	Provides a systematic and objective approach in assessing hazard and their associated risks, provide an objective measure of hazard being identified and followed by risk control measures. It is apply to all type of industries in Malaysia.	None	None	Purpose, definition	Basic concept, planning & implementing HIRARC, documenting HIRARC, consultation and training.	Concept in conducting HIRARC
OSHMS MY (Occupational Safety and Health Management System, Malaysia)	To provide guidance for any organization or industries in Malaysia on the implementation of the MS 1722: 2011	None	Scope	Purpose, definition	The OSHMS in the organization.	Description of OSH management elements in organization
ICOP MY (Industrial Code of Practice, Malaysia)	To provide guidance for industry involve in confined space entry to prevent exposure to hazards and thereby prevent collapse, injury, illness or death arising from exposure to those hazards. Not apply to underground mining works and the space other than atmospheric pressure.	None	None	None	Preliminary, confined space entry programme, detail requirements and duties of responsible person.	Confined space entry programme and detail requirements.

2.0 Guidelines

All the Guidelines which has been summarized will be continued with further elaboration about their requirements and describe on its contributing factors towards confined space risk assessment.

2.1 UK Ministry of Defense Health and Safety Handbook: Safe Working in Confined Space

The Legislation requirements for MoD UK is illustrates in Table 2

Table 2 Guidelines Requirements of MoD UK

NO	REQUIREMENTS	CONTRIBUTING FACTORS		
		CONCEPT	SUITABILITY	RELEVANCE
1	Roles and duties	Summarize roles and duties of Authorizing Engineer, Authorized Person, Person in Charge and Work Team	The role of each personnel for confined being outlined could be used as a reference and guideline for appointing key personnel for confined space.	It is part of the risk control measures and it is much related to the risk assessment process for confined space by considering its requirements in the process of developing risk assessment tools .
2	General Arrangements	Describing the nature of confined space, initial classification to define features of confined space, categorization of confined space and safe work procedures.	A brief description of confined space is suitable for management to plan for confined space occupancy by considering the prevention of risk to be faced.	The description of confined space is relevance due to the hazards generated by confined space is depending on the physical and type of work to be carried out in order to conduct an effective risk assessment process.

3	Management arrangements	Listing the arrangement by management for Confined space document centre, confined space register, confined space schedule, confined space records, equipment register, key register, management of remote sites, safety sign and safety rules book.	The approach to manage a documentation and records for confined space is suitable to be referred to ensure it is traceable if there is any changes to be made.	The effectiveness in managing a documentation is not much related to the process of risk assessment but it contribute to the revise history of records.
4	Operational procedures	Explaining the requirements to adhere prior entry such as risk assessment, level of control, safety program, permit to work and procedure to entry.	It is much suitable to be referred as key elements prior confined space entry especially on the determining the level of control of an Authorized persons of confined space and procedure for management of an entry into confined space.	The requirements being described is related to the process of risk assessment for confined space by providing a several samples of forms and likelihood, severity and risk action table.
5	Training	Requirements for training for Authorized Engineer, Authorized Person, Person in charge and Work team..	The training requirements for related personnel for confined space is compulsory and the example list of training standard is suitable to be referred as basic guidelines.	The training requirements which part of under administrative control is relevant to be used as an input for risk assessment process for confined space.
6	Health requirements	Fitness level of employees, correct method of wearing PPE and viral infections.	It is suitable requirements to be referred by employers to ensure all workers involve in hazardous atmosphere is healthy and free from infected diseases.	The health requirements is an important part to be included in risk assessment for confined space especially when expose to toxic atmosphere and viruses.

2.1.1 A Review of MoD UK

Referring to the MoD UK Guidelines being reviewed, the main objective of this Guideline is to ensure safe working for confined space works for UK Ministry of Defense. The objective is similar to others Guidelines where by securing health and safety of workers in confined space works, it will result in increasing safety performance in workplace. The roles and responsibilities also play a vital role where it will pursue a personal responsibility towards health and safety. This Guideline also has explained about the pre-assessment on the physical condition of confined space prior plan for entry. Comparing to the other requirements, the practice is suitable to be practiced to all confined space works. For ensure it is assess in more effective ways, the usage of Checklist and Competent Personal involvement is recommended. Documentation system being stated in this Guideline is categorised as good approach to fulfil. On top of that, close follow up and monitor on the implementation of that practice is required. The operational procedures being outlined in this Guideline is an effective method in identify risk in confined space activities. The overall safe work system revealed in this Guidelines shows it could lead to effective method in controlling risk and action to be taken. Even the risk matrices table is a 4 X 4 method, it is observed still practical to be utilized. For future recommendation, it advisable to use a 5 X 5 risk matrices table for a wider range of risk estimation. Training of personnel for confined space works is part of requirements to be adhered.

The training Standard Table provided in this Guideline is useful as reference for other confined space requirements. One of the issues in training program faced by industry such as construction is a high turnover rate of workers. Another requirement stated in this Guidelines is the health requirements of workers involve in confined space works. This is due to the nature of confined space where required only fit person could enter for carrying out jobs. For that instance, the medical check up need to be carried thoroughly by certified occupational health doctor. Another matter to consider is how to ensure the quality of risk assessment being carried out. For that instance, Pinto *et al*., (2013) studied about ensuring the quality of risk assessment by examine the current occupational risk assessment concept in order to improve its quality and relevant to the assigned task.

2.2 Health and Safety Executive UK: Confined Spaces, A Brief Guide to Working Safely

The Guidelines requirements for HSE UK is illustrates in Table 3.

Table 3 Key Guideline Requirements of HSE UK

NO	REQUIREMENTS	CONTRIBUTING FACTORS		
		CONCEPT	SUITABILITY	RELEVANCE
1	What is confined space	Definition of confined space, type and categories of confined space.	The explanation of confined space definition provide useful knowledge and information for industries in identifying their hazardous workplace.	Different type of confined space contribute to different type of hazards which it is important information need to be collected while conducting risk assessment process.
2	What are the dangers from confined space	List the dangers in confined space which arise from hazardous atmosphere and occupational hazards	The list of dangers being stated could be used by industries as a useful guidelines prior confined space entry.	A basic input on the dangers arise in confined space is much related in the developing process of confined space risk assessment tools.
3	What the law says	Risk assessment requirements by Health and Safety at Work Regulations 1999	The general arrangement of risk assessment and the proposal on the preventive measures for working in confined space is useful to be referred prior entering confined space.	The input from the laws about confined space risk assessment is relevant to the process of risk assessment for confined space works.
4	Avoid entering confined space	Propose an alternative ways to carry out works in confined space such as using robotic method or special devices..	The consideration in deciding whether it is required to enter confined space is a useful guide for employers in minimizing the risk might expose to their workers.	The decision making for confined space entry determination is relevant to be used as an input in risk assessment process for confined space.
5	Safe system of work	Describe safe system of work such as appointment of Supervisor, selection of workers, Permit to Work, testing of atmosphere, breathing apparatus, communication and emergency response.	The elements of safe system of work is useful to be practice at workplace to ensure all person involve in confined space works are being prevented from accident.	The contribution input from safe system of work is much related to the confined space risk assessment tools to be develop due to the critically of information being obtained.
6	Emergency procedures	Requirements during emergency situation such as Emergency response & preparedness, rescue team and rescue equipments	Emergency response and preparedness is part of the important criteria to be practiced prior confined space entry and the information is useful guide for employers as their priority.	The emergency procedure is much related to the risk assessment activities for confined space and the inputs of each elements would contribute in minimizing risk during emergency situation.
7	Capabilities of rescuers	Requirements for Rescue team competency and ability to response effectively during emergency	The requirements outlined the responsibilities of employers to provide a required competency for rescue team as well as fire drill exercise.	The competency of rescue team will be part of the elements in the risk assessment checklist in order to identify the risk level during occupancy in case of any emergency.

8	The law	Confined Space Regulations 1997, The Provision and use of Work Equipment Regulations 1998 (PUWER), Workplace (Health, Safety and Welfare) Regulations 1992, The Personal Protective Equipment Regulations 2002	The list of laws being stated is useful for further information and improvements on safe work system being implemented.	The additional information on the law is contribute as an additional input in developing a confined space risk assessment tools.

2.2.1 A Review of HSE UK

The HSE UK Guideline on safe working in confined space is established to provide a basic guidance for industry in complying to safety rules while working in confined space. The Guideline is simple and easy to understand. The categorization of confined space gives basic information on the type of confined space. It is to prevent any confusion in determining works in confined space. While carrying out jobs, an example of hazard situation is explained to remind about danger of confined space. In certain circumstances, work in confined space also can be avoided through another alternative. The employer needs to assess the type of works to be carried and decide the needs to enter confined space. This approach would reduce the hazards that might be exposed to the workers and prevent accident from occurring. The safe system of work also need to be implement adequately to ensure all elements being outlined is adhered accordingly. In case of any emergency situation, the rescue team will take part and the competency of the response team is vital to the work team. This Guideline also provides further references to enhance the safety and health in confined space by referring to the Act and Regulations. Since the Guidelines provide the basic information about confined space work safety, further information is needed especially in conducting risk assessment prior confined space occupancy especially on the type of tools to be implemented. From that point of view, a study by Vienney *et al*, (2016) stated about the comparison of four tools being develop for performing risk analysis in confined space environment in order to conclude the weakness and the distinctive parts of the tools.

2.3 British Compressed Gas Association: The Application of the Confined Space Regulations to the Drinks Dispense Industry, Rev.2, 2015

The Guidelines requirements for BCGA UK is illustrates in Table 4.

Table 4 Guideline Requirement of BCGA UK

NO	REQUIREMENTS	CONTRIBUTING FACTORS		
		CONCEPT	SUITABILITY	RELEVANCE
1	Key properties of gases used for drinks dispense	Listing of key properties of gases such as carbon dioxide, nitrogen, air and mixed gases including the hazards of each gas if accidentally release to atmosphere.	The explanation on the risk of gases by presenting its concentration, effects & symptom is a useful guidance prior entering confined space especially for carbon dioxide and nitrogen	The gases being presented is a common toxic gas exposure in confined space and it is much related to confined space works and developing an effective risk assessment tools.
2	The confined space regulations	HSE L101 (5), Safe work in confined spaces, Approved code of practice and HSE INDG 258 ((9), Safe work in confined spaces.	The approach is towards reference to relevant regulation for confined space works in UK. Reference made by other countries is according to the suitability of the regulation and works to be carried out.	The Laws being referred is observed as additional information in complying to safe working in confined space.

3	Assessment of risk	The gas concentration calculation, factors which affect the overall assessment and procedure for the calculation of risk	The method in conducting pre-risk assessment is suitable to be practiced such as calculation of carbon dioxide concentration in air and classification of risk categories.	Preparation towards the assessment of risk is much related to confined space works where it could be an input for developing risk assessment tools.
4	Actions resulting from assessment	Procedure for tolerable risk, medium risk and high risk including action to be taken is described clearly.	The explanation on the action to be taken on each risk categories is practical to be used as reference during risk assessment process.	The elements of risk action categories is much related to the confined space risk assessment tools and it would be an additional input during tools development stage.
5	Competence and training	Requirement for competency training to all related personnel.	It could be used as pre-assessment checklist prior confined space entry and is one of the important elements to be adhered.	It is a pre-condition for every personnel for competency training and the approach is directly related to confined space risk assessment process.
6	Personal protective equipment	The personal protective (PPE) requirements which stated in Personal Protective Equipment at Work Regulation (2)	The requirement of PPE including the correct selection of PPE is compulsory for every personnel and is suitable to be enforce and practice prior confined space entry.	It is an additional input for risk assessment process especially related confined space activities.

2.3.1 A Review of BCGA UK

Toxic atmosphere is always related to confined space entry either generated from the activities or vapors accumulation inside the confined area. Any works involve toxic gases or flammable gases required further assessment of risk prior start any activities. The BCGA guidelines aware on this hazards and it has develop a set of guidelines which suit to the confined space in drinks dispense industry. The hazardous gases such as carbon dioxide is explain on its characteristics and exposure. Same as to flammable gas such as air which would become spontaneous explode if release more than 23.5% enrichment. To combat those issues, a gas detection method is required to measure the level of particular gases in atmosphere. In risk assessment process, the guidelines describe on the procedure to calculate for gas and air concentration. The value obtained will be decided according to the established risk description category namely tolerable risk, medium risk and high risk. It the n followed by risk action on each of the risk level identified. To ensure all setting is effective, appointment of competent person is compulsory besides complying to personal instructions. The flow chart illustrated about gas risk reduction is another option to describe effectively about risk assessment strategy. In this guideline, the informative input is only at the assessment of risk including its action, competence & training and Personal Protective Equipment requirements. However the risk assessment concept still have its own limitation due to scope of application is specific for the usage of this Guidelines. A study on the occupational safety related to hazardous confined space environment has been conducted where it clearly explain about the toxic gases, air testing, ventilation, personal protective equipment, isolation and rescue (Ana Stojkovic, 2013).

2.4 American Society of Heating, Refrigerating and Air-conditioning Engineer (ASHRAE), Guideline for the Risk Management of Public Health and Safety Buildings 2009

The Guidelines requirements for ASHRAE US is illustrates in Table 5

Table 5 Key Guideline Requirement of ASHRAE US

NO	REQUIREMENTS	CONTRIBUTING FACTORS		
		CONCEPT	SUITABILITY	RELEVANCE
1	Risk management approach	General approach of risk management of an organization including risk assessment process, risk management plan implementation and re-evaluating the plan after implementation	The risk management framework being referred for risk management is part of the elements that could be used in the planning for conducting risk assessment. The risk management methodology being provided would serve as an additional input for risk assessment process.	It is much related in the stages of developing a risk assessment tools especially on the information of risk management methodology.
2	Design for new and existing facilities	General concepts towards the protection of occupants in the facilities which consider the requirements for site planning & design, utility system, building planning & design and building occupancy types.	The method in determining a risk level could be used as an example for risk estimation process.	The qualitative method in determining risk is relevant to be used as input for risk assessment process.
3	Operation and maintenance of buildings	Commissioning, documentation, public address system, site & building security, plan for normal operations, plan for emergency operations and personnel protection.	The approach is more towards the operation and maintenance except for the planning of emergency operation which is part of useful references.	Planning for emergency operation is observed as important elements to be referred in developing risk assessment tools

2.4.1 A Review of ASHRAE US

Base on the requirements being summarized, the Guidelines is established purposely for the risk management of public health and safety in buildings. However, the risk management approach outlined in this guideline is quite beneficial in the planning of any works related to confined space entry. The risk management framework and basic steps in risk management process has been explained in detail. For the design of new and existing facilities, the method in determining the risk level such as low, moderate and serious risk is superior approach. It also applies to the operation and maintenance process which focus on the risk action on every sub elements explained. The significant approach of this guideline is the quantitative and qualitative methods in assessing risk. A comprehensive example of risk assessment methodology is described clearly which starts from assessing the risk, identifying the risk, estimating the probability of risk occurrence, assessing the value of loss for risk assessment and ranking the risks. The risk assessment strategy in this Guidelines is quite comprehensive and it could serve as good reference for enhancing the risk assessment tools for any critical works in confined space. Other requirements in this Guideline is similar such as preparing stage and emergency response. In terms of the risk matrices presented either qualitative or quantitative, the method in utilizing it is quite important. Wrong concept of usage would lead to incorrect risk assessment results. The study about the recommendation on the use and design of risk matrices has been conducted where the objective is to explore the weakness and provide recommendation on its use and design (Duijm, 2015).

2.5 Industrial Code of Practice for Safe Working in Confined Space 2010 (ICOPMalaysia)

The Guidelines requirements for ICOP Malaysia is illustrates in Table 6

Table 6 Guideline Requirements of ICOP Malaysia

NO	REQUIREMENTS	CONTRIBUTING FACTORS		
		CONCEPT	SUITABILITY	RELEVANCE
1	Confined space entry programme	Describe the responsibilities of employers to carry out confined entry programme which include hazard identification, risk assessment and risk control, stand-by person, monitoring of multiple confined space, permit system, sign-posting, employee training, equipment, means of communication, external hazard protection, identification of duties, information to contractors, coordination among contractors, conclusion of entry.	The list of confined space program is beneficial to be practiced by industry players in ensuring effective monitoring of confined space works especially on the hazard identification, risk assessment and risk control process.	The program being proposed could be referred as an input during initial stage of developing risk assessment tools for confined space works due to its relevance to the nature of working in confined space.
2	Detail requirements	Permit to work system, isolation requirements, safety of atmosphere requirements, entry into hazardous atmosphere, rescue & emergency services, health requirements of persons working in confined space, training, additional precautions during occupancy of confined space and record keeping.	Most of the requirements for working in confined space is described clearly and this is the key elements that need to adhere by industries prior occupancy.	The description of each requirements is much related to the assessment of risk prior confined space entry and the input from the risk assessment process would be used for developing risk assessment tools for confined space.
3	Duties of responsible person	Duties of employer as owner, duties of employer as contractor, duties of permit issuer, duties of entry supervisor, duties of authorized gas tester, duties of stand-by person and duties of authorized entrant.	All the responsible personnel for confined space is listed on its key duties and it is useful to be referred as a basic guidance in appointing key personnel for confined space activities.	The duties being outlined is part of the control measures (administrative control) which could be included in the process of developing risk assessment tools for confined space.

2.5.1 A Review of ICOP Malaysia

The ICOP being develop is purposely for giving a full guidance on safe working in confined space. The overall content of this guideline is adopted from the Australian Standard 2865. However in order to suit for Malaysian current industries demand, this ICOP has been develop and further improve from the previous 2001 Code Of Practice. The ICOP focus on the confined space entry programme such as hazard identification, risk assessment and risk control which has been explained in detail as well as emergency procedures. Furthermore, permit to work system also has been stress where in the permit issued, all the precautions before entering confined space is recorded and listed. On top of that, the duties of persons involve in confined space entry also has been described to ensure effective monitoring being carried out. The limitation observe is about the risk assessment process which it still referring to the HIRARC Malaysia Guideline and not specifically to confined space works. In Appendix, the risk assessment and permit to work form is provided and the most obvious changes is concerning health of workers. The additional recommendation in hot work, cleaning and atmospheric testing is a good approach of procedures to be referred. Another input is the emergency response preparedness related to confined space. If there is any accident occur, employer will liase with Fire Department

in rescue. However, the effectiveness of rescue is still not being measured. For that instance, a study by Wilson *et al*., (2012) has stated about the assessment on emergency response practices of employer and Fire Department where the outcome from this study could be used as a reference in enhancing rescue team effectiveness.

2.6 Guidelines for Hazard Identification Risk Assessment and Risk Control (HIRARC)

The Guidelines requirements for HIRARC Malaysia is illustrates in Table 7

Table 7 Guideline Requirements of HIRARC Malaysia

NO	REQUIREMENTS	CONTRIBUTING FACTORS		
		CONCEPT	SUITABILITY	RELEVANCE
1	Basic concept	Giving a brief description of risk and a mathematical equation of risk.	It is useful to understand the definition of risk prior proceed with risk assessment.	Mostly the equation of risk is used to all risk assessment process either specifically for confined space or others activities.
2	Planning and conducting HIRARC	Explaining the purpose of HIRARC, planning of HIRARC activities and process of HIRARC.	It is useful information which has been described especially during the process of HIRARC where the flowchart of HIRARC process presented is clear. During analyze and estimate risk, the table presented in detail the likelihood, severity, risk matrix and risk action.	The overall process of HIRARC is much related to the risk assessment of confined space and would add value during the development of risk assessment tools.
3	Control	Describing the definition of control, selecting suitable control, types of control, monitoring controls, safe work procedures and personal protective equipment	The hierarchy of control being presented is suitable for recommending a control measure during risk assessment process. The proposal to review the control and develop safe work procedures is an additional input to ensure effectiveness of risk control measures.	The approach on the risk control and additional relevant inputs is much related to the process of developing risk assessment tools for confined space.
4	Documenting HIRARC	Explaining the requirements for documentation such as responsibility & accountability and documenting process.	The method in documenting especially HIRARC documents is useful to be practiced to ensure all HIRARC process being conducted traceable in case of any changes required.	The documentation approach for confined space works is required especially on the PTW and risk assessment, even the documentation is not directly related in the development of risk assessment tools.
5	Consultation	Consultation with health and safety personnel and employees for effectively identifying and controlling risk.	Engagement with health & safety personnel and workers is required in collecting further information about the workplace hazards.	It is much related in the development of confined space risk assessment tools to ensure the information collected is genuine.
6	Training	Requirements about importance of training to all workers and management to ensure they have a knowledge and skills in identifying and controlling risks.	Training is part of important criteria required for every personnel and it is practical to be enforce to all personnel involve in confined space entry.	It is an additional elements to be added in risk assessment and is related in the developing confined space risk assessment tools.

2.6.1 A Review of HIRARC Malaysia

Hazard identification, risk assessment and risk control is one of the important criteria need to be carried out especially involving a high risk task such as confined space entry. The effort done by Department of Occupational Safety & Health Malaysia by developing HIRARC guidelines is beneficial reference for industries. The content of this guideline covering every steps needed in conducting HIRARC at workplace. The method describe during HIRARC process is easy to understand and flexible. The 5 X 5 risk matrices table being recommended is serve as a guidance and the user may select the suitable method according to the condition of their workplace. Risk control and action also being defined in a table form after risk rating has been determined. To ensure all personnel in organization is able to understand in conducting HIRARC, a proper training has to be planned. The documentation process also important where it could be used for tracking and for revising purpose in case of any process changes. For further improvement, the risk action table in this guideline need to be extended on its range for more option of control action. However the examples of HIRARC given is useful for the user as a minimum basic guidance in HIRARC process. Commonly, a risk matrices table is already given and the level of risk is determined base on the tasks. According to the recent study, different personal would give different result of risk level (Ball and Watt, 2013). Due to that, the decision to utilize risk matrices from the outcomes of the study is not relevant and untrustworthy.

2.7 Guidelines on Occupational Safety and Health Management System (OSHMS)

The Guidelines requirements for OSHMS Malaysia is illustrates in Table 8

Table 8 Guideline Requirements of OSHMS Malaysia

NO	REQUIREMENTS	CONTRIBUTING FACTORS		
		CONCEPT	SUITABILITY	RELEVANCE
1	Describing the OSH MS in the organization according to 5 Categories of OSH elements from ILO-OSH conceptual framework	**Policy-** Occupational Safety and Health policy requirements for every organization and how to formulate the policy. It also stated about employee participation in safety and health at workplace and how the participation strategy is undertaken by employer.	The requirements to establish a policy in organization is suitable to be implemented where it would show full commitment from employer with regards to health safety of their workers.	The policy being established would be used as a guidance in ensuring all safe work system is being practiced accordingly especially during the process of developing risk assessment tools for confined space.
		Organising- the responsibility, accountability and authority of an employee, competency, training & awareness and OSH MS documentation (ILO-OSH 2001 Implementation Manual) and about the important of communication amongst all personnel in organization.	This element could be use a reference in the effective ways of organizing the occupational safety and health management in workplace.	Effective organizing of workplace health & safety would resulted in a high standard of safety compliance which would indirectly contribute to teamwork spirit during the development process of risk assessment.

Planning and Implementation-Initial Review or gap analysis requirements, occupational safety and health objectives & occupational safety and health plan to ensure the direction is on track, hazard identification, risk assessment & risk control requirements, emergency prevention, preparedness and response requirements, management of change in organisation, procurement requirements and contracting requirements.	The element being outlined is useful to be referred and practiced in organization since it covered most of the hazard and risk observed in workplace with an additional elements consists of administrative approach.	The approach is much related in the process of risk assessment since it outlined the elements consists of hazard identification, risk assessment & risk control which could be used as an input for the development of risk assessment tools for confined space.
Evaluation-performance monitoring & measurement requirements, incident investigation, audit and management review.	The measurement of the safe work system implementation is part of the requirements to be conducted by employers in ensuring the effectiveness of the system which could be used for further improvements.	The sub-elements of the evaluation stage is to closely monitor the performance of safe work system in workplace which could be used and relate in enhancing the process of risk assessment for confined space.
Action for Improvement- preventive & corrective action and continual improvement requirements.	The findings from the performance measurements will be used as a basis for further improvements and the practice that management need to act pro-actively.	The elements from action for improvements is not directly related to the risk assessment process but the continual improvement concept being practiced would give a useful input for enhancing risk assessment tools for confined space.

2.7.1 A Review of OSHMS Malaysia

The OSH MS Guideline outlines all aspect about the requirements of Occupational Safety and Health Management System. Most of the guideline content is adopted from ILO-OSH 2001 standard which consists of Policy, Organising, Planning & Implementation, Evaluation and Action for Improvement. Every each of the elements has their own function and the safety performance of organization is measured from those achievements. In safety and health policy establishment in organisation, the written commitment in the policy need to realize it conveying the message to all level of employees which has been clearly defined in this guidelines. Furthermore, the competency and awareness of all workers is required to ensure all matters relating safety is complied accordingly. Every critical jobs especially confined space entry required to conduct a risk assessment process. As being mentioned in this Guidelines, the process of risk assessment is include Hazard Identification, Risk Assessment & Risk Control. To ensure any workplace is performing as planned, the process of monitoring and measure the safety & health performance need to be done periodically. On top of that, in case of any emergency situation, emergency response plan is required to control and normalize the situation. For a continual improvement in occupational safety & health, any observations or findings need for further action such as preventive action as well as proper records and documentation. Even this guideline is focus on OSH Management system, the elements being described is useful for an input for risk assessment strategy for confined space works. The hazard identification, risk assessment and risk control approach in this Guideline also observed similar to the HIRARC Guidelines. However the sample forms and checklist provided can be refer as a useful guidance for further improvements. Moreover, to ensure the implementation of OSH management system is effective, full support from higher management is summoned. In other words, the influence from higher management could lead to positive outcomes it would indirectly reduce the risk where being faced in the workplace. Due to that, a study which has been conducted by Kirsten Jørgensen and Nijs Jan Duijm, (2011) is to assess the potential risk that lead to an accident and the way to promote safety awareness to all workers by improving its risk assessment approach. As an example in this study, two occupations were identified and the risk profile of each trades are collected and analyzed. From the information gathered, the proposal in promoting effective risk assessment for employers and employees are achieved.

3.0 Comparison of Guidelines

The seven Guidelines being reviewed will be compared to its risk assessment elements being stated in each Guideline. The outcomes from the comparison will trigger in enhancing the risk assessment method prior plan for working in confined space. Referring to the risk assessment comparison on each Guidelines, MoD UK, BCGA UK, ASHRAE US, ICOP Malaysia and HIRARC Malaysia directly presented their risk assessment element concept whereas HSE UK and OSHMS Malaysia presented it indirectly through established management concept approach. It also could be defined that each Guidelines has their own approach in conducting risk assessment. MoD UK conducting its risk assessment by referring to HSE Code of Practice L101 and supporting by a set of forms. Prior confined space entry, risk rating is determine by referring to likelihood and severity scale. In addition, permit to work is applied and supplemented by relevant checklist. For HSE UK Guideline, it spells in general regarding safe working in confined space without specific method in assessing risk. In the case of BCGA UK Guideline has its own method in calculating risk specifically for drinks dispense industry. It also includes its own risk category and control action. For ASHRAE US Guideline, it provides a comprehensive method in assessing risk. The quantitative and qualitative method used is the best approach by this Guideline specifically for the management of risk in Public health and safety of buildings. Prior to that, it also explains about the risk management framework which is useful for the management of risk in organization. ICOP Malaysia Guidelines' risk assessment approach is detail out in the confined space entry programme. The procedure in assessing the risk is respecting to the confined space works and the method in estimating the risk is according to HIRARC guideline. For HIRARC Malaysia guideline, it is solely for the hazard identification, risk assessment and risk control. The method in conducting HIRARC is explains in detail. The likelihood and severity table is provided to determine the risk level and risk matrices and risk action table is used for risk control strategy. Finally for OSH MS Malaysia Guideline, it mentioned about risk assessment requirements in the planning & implementation stage. The approach in conducting risk assessment is similar to HIRARC guideline including its likelihood, severity, risk matrices and risk action table. From the comparison, it could be concluded, every Guideline has its own method and concept in assessing the risk specifically to suit the purpose of the Guideline. The best risk assessment in confined space works is from Mod UK Guidelines. This can be observed through the arrangement of the safe work system presented and including the flowchart, diagram and sample of assessment forms. In terms of risk assessment techniques, ASHRAE US is a good example due to the qualitative and quantitative approach being presented throughout the Guidelines. In order to improve our Malaysian safe work practices for confined space, the examples of the method in assessing risk and other relevant inputs from the Guidelines could be integrated to ensure the risk assessment tools being develop is practical and suit for all tasks in confined space. On top of that, the hazards that appeared from the works carried out need to be well recognized and act accordingly. This issues is apply to all type of work sites to ensure it is well manage since most of workers will be present at their place of work. The importance of hazard recognition and risk perception is mentioned in a study where it measures the ability of management personnel to recognize and perceive risk in their routine workplace (Perlman *et al*., 2014). Recent study also showed that the main contribution towards fatality in confined space in Canada is due to hazardous atmosphere (Vienney *et al*., 2014).

4.0 Conclusion

The seven Guidelines namely, MoD UK, HSE UK, BCGA UK, ASHRAE US, ICOP Malaysia, HIRARC Malaysia and OSH MS Malaysia being reviewed has been clearly described on their Guideline requirements. On each Guideline requirements, it can be observed the important approach on risk assessment element specifically conducted for the purpose of the Guideline. The review on every Guideline revealed that, every Guideline has its own contribution elements on risk assessment especially in risk assessment methodology for confined space works. Eventually for a comparison of Guidelines which specifically focus on risk assessment elements, it is observed that every Guidelines has its own unique method in assessing risk it could be used to improve our Malaysian safe work practices for confined space. For that instance, every best approach of risk assessment concept identified is useful and could be integrated for the basis for enhancing risk assessment tools for confined space works. Finally, several literatures which have been referred also could give a useful input for improvements strategy.

Acknowledgment

The authors wish to express the greatest appreciation and utmost gratitude to the Ministry of Higher Education, UTM Razak School of Engineering & Advanced Technology and Universiti Teknologi Malaysia (UTM) for all the support given in making the study a success. UTM Vote No: Q.K130000.2640.11J20.

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Identification of Hazardous Nature of Well Drilling Operation With Associated Potential Hazards at Oil and Gas Extraction Industries: an Explanatory Approach

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Abstract: *This study illustrates about the most hazardous and risky activities associated with well drilling operation at on and offshore oil and gas drilling sites by adopting exploratory research design (quantitative leading to qualitative). In this study researcher has targeted three oil and gas industries each from Malaysia, Saudi Arabia and Pakistan for the identification of associated hazards and nature of hazardous activities faced by drilling crew during well drilling operation. Eighty (80) drilling crew members have been randomly selected for answering the survey questionnaire. Likewise, nine (09) drilling health and safety officials have been conveniently selected based on their safety expertise in oil and gas drilling field for semi structured in-depth interview. For analyzing quantitative findings descriptive statistical methods has been used. While for qualitative section thematic analysis approach has been utilized. Based on the findings, respondents from Malaysian oil and gas industries reported starting drilling activity as highly hazardous at onshore well drilling, while handling drilling pipe has been considered more hazardous activity at offshore domain. Similarly, in the context of Saudi Arabia, respondents highlighted that the handling drilling pipes are cause of major injuries at onshore well drilling site. Whereas drilling fluid preparation and coring process is considered harmful at offshore sites. In contrast, participant from Pakistan indicated coring process as a highly hazardous activity at on and offshore well drilling operation. According to overall results based on the participant response, oil and gas well drilling operation at onshore domain is considered more hazardous at Pakistani oil and gas industry as compare to other targeted industries with mean range 3.42. While for offshore well drilling, Malaysian industry is recorded highly hazardous as compare to others leading with mean value 3.39 and related with chemical and safety hazards in well drilling activities.*

Keywords: *Well drilling operation, exploratory research design, occupational health and safety.*

1.0 Introduction

Oil and gas industries play a significant role for the prosperity and expansion of the national economy from decades [1]. But, oil and gas extraction process is always considered as a most risky and hazardous job in oil and gas field [1, 2]. This petrochemicals drilling process are starts from rig assembling in which contractor or company fixed the drilling rig and equipments at place where they are willing to drill after geological examinations and ends upon well control and production operations after performing well drilling and at on and offshore drilling sites [3]. Every year several incidents and severe accidents have been reported during performing drilling activities and its associated operations due to unpredictable nature of this profession [3]. In fact, according to the Megan in year 2013, the death rate among oil and gas workers (drilling crew) have now nearly eight times higher than the all-industry rate of 3.2 fatalities for every 100,000 workers [10]. As far health and safety concern, oil and gas industries spend millions of dollars for the protection and safety of their drilling workforce by appointing health and safety experts and professionals at drilling domains [5, 6]. Every activity associated with well drilling such as handling drilling pipes, preparing drilling fluids and coring process are lead to several safety, ergonomic and chemical hazards.But due to the hazardous nature of this profession ,lack of professional expertise, lack of updated preventive measures and unsufficent identification of potential hazards, every year hundred of peoples suffered with critical (major) injuries during well drilling operation. Whereas, oil and gas industries also faced expensive property damage due to the lack of proper safety[7].

1.1 Problem Statment

Well drilling operation which is the second major drilling operation after rig assembling is considered as most risky and highly associated with health and safety related concerns and issues [6]. The well drilling operation which is further divided in to four sub activities such as, handling of drilling pipes activity, preparation of drilling fluids activity, starting drilling and coring process [4]. But, during performing these well drilling activities at on and offshore drilling process well drilling crew members have to face life threatening hazards and challenges due to the lack of reorganization of hazardous nature of well drilling at both on and offshore domains [6, 5]. There is also a sheer need for assessing and identifying the most potential hazards and their characteristics which can cause injuries and life time disabilities. These risk assessment and hazard reorganization will guide health and safety experts and practitioners to implement preventive measures for elimination of well drilling hazards [9,10]. Therefore, this paper discusses about the

most hazardous activities during well drilling operation with their associated potential hazards and characteristics at on and offshore oil and gas industries from Malaysia, Saudi Arabia and Pakistan by using exploratory research approach.

1.2 Study Objective

The Main objectives of this study are reported below:

1. To recognize the hazardous nature of well drilling activities at on and offshore drilling operation among Malaysian, Saudi Arabian and Pakistani oil and gas industries

2. To investigate the potential hazards associated with these hazardous activities during well drilling operation at Malaysian, Saudi Arabian and Pakistani oil and gas industries.

1.3 Research Question

The following questions have been designed to achieve the answers of proposed objectives are listed below:

1. What are the most hazardous nature of well drilling activities among on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan?

2. What are the Potential hazards associated with well drilling activities among on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan?

2.0 Methodology

In this study, eighty (80) oil and gas drilling crew members have been randomly selected from three targeted oil and gas industries from Malaysia (PETRONAS), Saudi Arabia (Saudi Aramco) and Pakistan (OGDCL) to participate in quantitative research of this study. Similarly, three (03) health and safety drilling experts and professionals have been conveniently selected for in-depth semi structured interview based on their broad working experience at on and offshore oil and gas industries from each targeted industry as shown in Table 1. Exploratory research design has been adopted for achieving proposed objectives of this study. For the quantitative data analysis descriptive statistical method (Mean, Standard deviation and Percentage) have been carried out through SPSS.22.Likewise, thematic analysis approach has been used for the analyzing the most potential hazard during well drilling operation in qualitative research of this study.

Table 1 Participant of Study

Country	Industry	No of Respondent	
		Quantitative	Qualitative
Malaysia	PETRONAS	80	03
Saudi Arabia	Saudi Aramco	80	03
Pakistan	OGDCL	80	03
Total		240	09

3.0 Quantitative Results

To answer the quantitative part of first and second research objectives and research question of this study descriptive statistical research approach has been adopted for the identification of hazardous nature of well drilling activities among on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan. Thus, for the justification and answer the research question, a table of specifications is adapted from Landlell 1997 as guide to measure the nature of hazardous activity during well drilling operation based on the level of mean range [11]. As shown in Table 2.

Table 2 Level of Hazardousness

Category	Mean Range	Hazardousness Level
1	1.00-2.33	Low
2	2.34-.3.67	Moderate
3	3.68-5.00	High

3.1 Recognition of Hazardous Nature of Well Drilling Activities

In the perspective of Malaysian oil and gas industries based on quantitative response from drilling crew members as shown in table 3. According to the findings most of hazards has been reported during starting drilling with mean range 3.25 and preparing drilling fluid activity as per the response from drilling crew and safety officers during onshore well drilling operation which is also lying under moderate level of mean 3.22 range. While, nature of drilling fluid preparation activity has reported as more hazardous activity during offshore domain of well drilling operation with moderate level of mean range which is 3.52, as in Table 3.

Table 3 Response on Well Drilling Operation at Malaysia

Activities	Onshore	Offshore
Handling of Drilling Pipes	Mean=2.95 SD=0.782	Mean=3.45 SD=0.552
Preparing Drilling Fluids	Mean=3.22 SD=0.733	Mean=3.52 SD=0.505
Starting Drilling	Mean=3.25 SD=0.808	Mean=3.20 SD=0.686
Coring Process	Mean=3.20 SD=0.686	Mean=3.40 SD=0.496
Total	3.15	3.39

Likewise, response from onshore Saudi Arabian oil and gas industry illustrated that the activity of handling of drilling pipes especially when drilling is in process is highly hazardous then other well drilling operation associated activities which is under moderate level of mean with range of 3.40. Correspondingly, Resuming drilling operation is considered more hazardous during offshore well drilling operation as per response from drilling crew and safety officers at Saudi Arabian oil and gas industry with mean score 3.47 at offshore drilling site under moderate level of mean range as per Table 4.

Table 4 Response on Well Drilling Operation at Saudi Arabia

Activities	Onshore	Offshore
Handling of Drilling Pipes	Mean=3.40 SD=0.955	Mean=3.27 SD=0.846
Preparing Drilling Fluids	Mean=3.15 SD=0.892	Mean=3.40 SD=0.744
Starting Drilling	Mean=3.15 SD=1.02	Mean=3.32 SD=0.764
Coring Process	Mean=3.22 SD=0.767	Mean=3.40 SD=0.81
Total	3.23	3.34

Lastly, in the prospective of Pakistani oil and gas industry based on quantitative survey response from drilling crew at on and offshore well drilling sites as shown in Table 5.The quantitative findings of this study indicates that the coring process is considered as most risky and harmful at both onshore and offshore well drilling operation with moderate level of mean score, 3.57 at onshore and mean range 3.45 at offshore well drilling operation as table 5 indicates.

Table 5 Response on Well Drilling Operation at Pakistan

Activities	Onshore	Offshore
Handling of Drilling Pipes	Mean=3.32 SD=0.797	Mean=3.17 SD=0.712
Preparing Drilling Fluids	Mean=3.45 SD=0.677	Mean=3.40 SD=0.671
Starting Drilling	Mean=3.35 SD=0.662	Mean=3.40 SD=0.632
Coring Process	Mean=3.57 SD=0.635	Mean=3.45 SD=0.782
Total	**3.42**	**3.35**

3.2 Identification of Potential Hazards Associated with Well Drilling Activities

Quantitative findings of potential hazard associated with well drilling operation at Malaysian, Saudi Arabian and Pakistani Oil and gas industries are shown in table 6. According to the result, 28% respondent from Malaysia oil and gas industry, 38% from Saudi Arabia, 48% which is highest is from Pakistani onshore oil and gas industry considered chemical hazard is potential hazard during well drilling operation. Similarly, 60 % of them from Malaysia and 30% from Saudi Arabia and 45% from Pakistani oil and gas industries specified that the chemical hazard is a major cause of injuries during offshore well drilling operation.

While, from Malaysian onshore oil and gas industry 72%, Saudi Arabian 62% and Pakistani 52% of them indicated that safety hazard is potential hazard. Same as, 40 % of them from Malaysia and 60% from Saudi Arabia and 55% from Pakistani oil and gas industries specify that safety hazard are potential during well drilling as shown in Table 6.

Table 6 Hazard Associated with On and Offshore Well drilling Operation

Activities	Domain	Chemical Hazard	Safety Hazard
Malaysia	Onshore	28%	72%
	Offshore	60%	40%
Saudi Arabia	Onshore	38%	62%
	Offshore	40%	60%
Pakistan	Onshore	48%	52%
	Offshore	45%	55%

As per, overall result of well drilling operation indicates that all total mean score range of well drilling activities at targeted industries are moderately hazardous. But, Pakistani onshore well drilling operation overall mean score is highest among of the rest countries which is 3.42 and under moderate level of mean range. But on other side, overall response from participants of Malaysian oil and gas industry specified that the well drilling operation is considered as more hazardous and risky at offshore drilling process as compare to other targeted industries with total mean range of 3.39, which is also lying under moderate level. Moreover, participants from all targeted industries have reported potential chemical and safety hazards as major cause of injuries during quantitative survey.

4.0 Qualitative Research

In order to find out the perception of health and safety drilling professionals regarding potential hazards which they deal mostly during on and offshore well drilling operation. For the analysis of qualitative data, thematic analysis approach has been implemented for semi structure interviews from targeted respondents by assigning code number for recognizing the industry and country, as shown in Table 7.

Table 7 Respondents Interview Code

S.NO	Malaysia	Saudi Arabia	Pakistan
1	MY01	SA1	PK1
2	MY02	SA2	PK2
3	MY03	SA3	PK3
Total	**03**	**03**	**03**

4.1 Safety Hazards Associated with Handling Drilling Pipes

According to the qualitative findings most of the respondent highlighted that the stuck hazard is most potential and usually happened, when drilling crew use to latch drilling pipes with elevator, which facilitates them to hold and lift pipe during well drilling as shown in block diagram Figure 1. As per respondent MY1and SA2 and PK2 from targeted oil and gas industries identified that the stuck hazard most occurred during onshore well drilling operation. But rest of the respondents from Malaysia, Saudi Arabia and Pakistan claimed that they usually experienced these hazards during offshore operation then onshore. At the other side respondent MY1 and PK3 is agreed that these hazards has been noticed in both industrial domain and it cause hand and feet fractures and physical injuries due to stuck between the pipes or walking on top of them.

Likewise, interview respondents from targeted industries also indicated that the falling tubular hazard is also have been harmful for workers and as well as for industrial property. As respondent MY1, PK2 and PK3 have point of agreement on fall hazard which indicates that at offshore well drilling operation during lifting tubular most of the time tubular has been fallen from the pipe rack and sometime from elevator if there is no proper latching between them. However, respondent MY3, SA1 and SA2 has been agreed on this point that falling hazard is consider as most potential hazard and cause of life threatening injuries during handling pipes at on and offshore well drilling. Similarly, knock on the sling wire is also specified by the interview respondents from all three targeted oil and gas industries. Interview respondent MY2, SA3 and PK1 from targeted oil and gas industries were agreed that, during drilling pipes handling crew accidentally knock on the sling wire which is used to lift the tubular, due to lack of barricade or signage which leads to deep face and hand injuries at on and offshore well drilling sites.

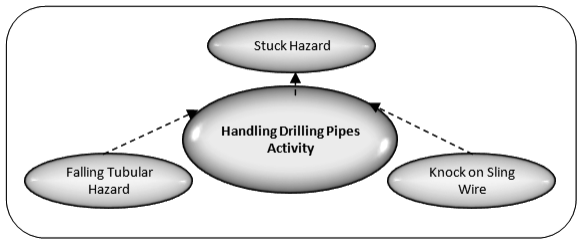

Figure 1 Block Diagram for Handling Drilling Pipes Hazard

4.2 Chemical Hazards Associated with Drilling Fluid Preparation

Based on the interview response participants from targeted industries were mutually agreed on chemical dust hazard during mixing and processing mud which is normally a cause of eyes irritation, skin infections and respiratory problems. Interview participant MY1, SA3, PK1 from targeted oil and gas industries have considered mixing and preparing drilling fluid activity during well drilling operation as one of the potentially hazardous activity at onshore sites

rather than offshore with associated chemical hazards due to splashes and dust of toxic chemicals. On the other hand, interview respondent MY3, SA3 and PK2 have highlighted that the chemical dust hazards mostly worker experienced at offshore operation. Correspondingly, participants from MY, SA and PK industries has been also indicated the chemical hazards due to caustic soda or weighting agent which is generally utilized by water base mud to boost as well as preserve pH and alkalinity. Participant MY3, SA2 and PK2 reported it is hazardous during onshore operation. While, participant MY1, SA1 and PK3 have specified it is harm and cause for major skin problems during offshore fluid mixing activity.

Lastly, during preparation of drilling fluid participant from MY2, SA1 and PK3 from targeted oil and gas industries have mutual agreement on skin and eyes irritation problems due to unprotected interaction with calcium bromide during on and offshore shore drilling fluid preparation as shown in Figure 2. Calcium bromide which is the calcium salt powder that reacts with water to form the hexahydrate and mainly used in drilling fluid and handled with proper safety precautions standardized by OSHA.

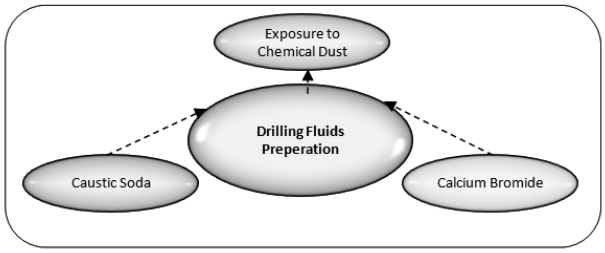

Figure 2 Block Diagram for Drilling Fluids Preparation Hazard

4.3 Safety Hazards Associated with Starting Drilling Activity

Base on the qualitative findings, respondents from above mentioned industries have reported drop object hazard due to top drive hard vibration during drilling is usually one of the reason in starting drilling activity as shown in Figure 3. Basically top drive utilize as a mechanical apparatus on a drilling rig that provides clockwise torque to the drill string to ease the procedure of drilling well bore and if the there is some mechanical problem so it drop that string and drilling pipe during boring which leads to critical injuries and death. As per the interview participant MY1 and SA3 have mutually argued that, drilling crew usually face drop object hazard during onshore operation. While, participant MY3 and SA2 have claimed that these drop object hazard mostly happened at offshore well drilling due to unconditional environment and faulty top drive equipment. Although, respondent PK1 from Pakistani oil and gas industry have pointed out that the drop object hazard which leads to injured crew members and damage the expensive top drive equipment is equally hazardous for both on and off operation.

Consequently, borehole instability is mostly considered as a major source of on and offshore hazards. As Interview participant MY3 from onshore and MY2 from onshore Malaysian oil and gas industry have highlighted occurrence of well instability hazards which put crew members and drilling infrastructure in risk. Meanwhile, participants SA1 from Saudi Arabia and PK2 from Pakistan has pointed out borehole collapse hazards correspondingly hazardous during on and offshore well drilling due to mechanical failure, erosion by fluid circulation and chemical interaction of borehole fluid which lead to stuck pipe hazards.

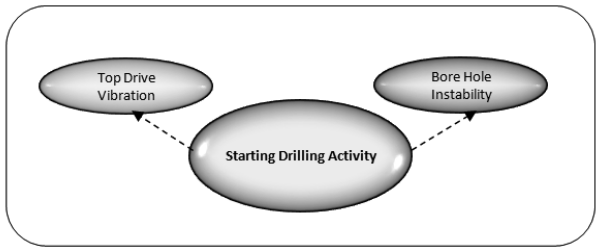

Figure 3 Block Diagram for Starting Drilling Hazard

4.4 Safety Hazards Associated with Coring Process

As per the results, participants from MY, SA and PK have specified injuries associated with coring process due to physical contact with radioactive materials in well drilling operations. According to the response from participant MY1, MY3 from Malaysia, SA1 from Saudi Arabia and PK2 from Pakistan indicated that the health problems during onshore coring due to harmful radioactive materials which are related with respiratory and skin issues. But respondent SA3 from Saudi Arabia and PK1 from Pakistan pointed out that, they use to experience these hazards at offshore and due to contact with these radioactive materials workers at high risk of exposure including those who handled drilling pipes and that might have been contaminated with sludge, drilling mud, and toxic chemicals. Likewise, participant from targeted industries equally agreed that, they also have notified stuck hazards due to core barrel during coring process. Participant SA2 from Saudi Arabia and participant PK2 from Pakistan have point of agreement that stuck by core barrel hazard are reported at onshore sites which leads to expensive core barrel damage also source of physical injuries to drilling crew. But on other side participant MY2 from Malaysian oil and gas emphasized on stuck by core barrel during offshore well drilling.

Respectively, damaged coring pipe hazard is also taken in to account by overall participants from focused industries as illustrated in Figure 4. Participant MY2 from Malaysia and PK1 and PK 3 from Pakistan have been recognized these hazards during onshore operation but on other side participant MY1 and MY3 from Malaysia and PK2 from Pakistan experienced these hazards at offshore site. As per the participant, these damage coring pipes are one of the sources for hand and finger injuries and also linked with fall and trap hazards because during offshore operation there is lack of space on the rig and if these pipes are gathered aside on rig which sometime trapped some workers on derrick.

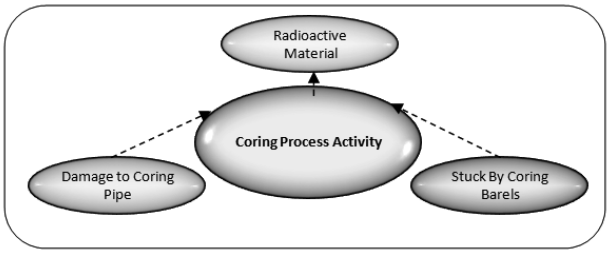

Figure 4 Block Diagram for Coring Process Hazard

5.0 Conclusion

In this study, according to the overall finding from targeted industries based on quantitative and qualitative analysis it has been indicated that the well drilling operation is equally considered as hazardous and cause of major accidents in all nominated countries. Similarly, it is also illustrated from the results and analysis that the respondents from Pakistani onshore oil and gas drilling domain reported well drilling as more risky operation as compare to Malaysian and Pakistani well drilling crew with mean range 3.42. While, well drilling crew members from Malaysian offshore oil and gas drilling sites have indicated well drilling operation have highly hazardous nature in contrast to other targeted industries with mean range 3.39 which is also lying under moderate level of mean range and associated with potential chemical and safety hazards in both on and offshore domains.

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Development of Physical Workload and Heat Stress Questionnaire for Construction Industry in Malaysia

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Abstract: *Geographically, Malaysia is situated in the equatorial region, thus having a climate of hot and humid throughout the year. Effect of heat stress and physical work load at construction industry need to be investigated because of the high number of accidents. Thus, perception of physical workload and heat stress by the construction workers in Malaysia needed to be investigated and documented. The aim of this paper is to establish a set of questionnaires containing the item generation regarding on physical workload and the heat stress perception of construction workers. Physical workload factors such as fatigue, risks, concentration, work rhythm, responsibility, satisfaction, and autonomy are inserted as the items in assessing the physical workload. While heat stress are assessed using heat risk factors such as temperature, humidity, heat radiation, air movement, workload, clothing and acclimatisation. A questionnaire has been developed resulted from various reviewing of literatures on physical workload and heat stress and better suited to the Malaysia working environment.*

Keywords: *construction, development, heat stress, physical workload, questionnaire.*

1.0 Introduction

Malaysia is situated in the South East Asia region and are well known for having a very hot and humid climate. According to a report from the Intergovernmental Panel on Climate Change (IPCC), the frequency and intensity of extreme heat episodes are expected to increase during the coming decades due to continued emission of greenhouse gases that cause further warming and long-lasting changes in all components of the climate system [1]. Workers in tropical and subtropical regions, many of whom are involved in heavy physical work outdoors or indoors without effective cooling, are at particularly high risk [2]. Workers exposed to a hot environment like construction workers are inclined to subjective fatigue, and their fatigue symptoms increase with the heat exposure levels [3]. Particularly, the construction industry in Malaysia shows a high rate of accidents, [4]. Thus, working people are at particular risk of heat stress because of the intrabody heat production caused by physical labour [4]. For example, the construction industry is found to be more susceptible to heat stress than other industries [5].

Construction workers have to perform highly demanding physical tasks with various types of stresses resulted from awkward posture, excessive force demands, highly repetitive actions and excessive energy expenditure [6]. For example, lifting heavy loads, plastering the wall, and bricklayering are the types of jobs commonly found in a construction site are inserted in the questioannaire.

Physically demanding works combined with the exposure to high temperature, humidity, solar radiation and poor air ventilation can further increase the physical stress of workers during the day-long operation [7]. Heavy physical workloads can also pose a threat of heat fatigue among construction workers, which is likely to increase the risk of accidents and injuries at construction worksites [8]. In addition, workers in construction industries may also suffer from high occupational temperature impacts on health and productivity due to climate change as researched by Kjellstrom [9].

Thus, the aim of this paper is to establish a set of questionnaires containing item generation regarding on physical workload and the heat stress perception of construction workers in high temperature climate such as in Malaysia.

2.0 Methodology

Methods used to meet the aim of this paper are by brief reviewing of the literature on the effects of occupational heat stress and physical workload with a focus on the South East Asia Region because Malaysia have the same climate as South East Asia countries. However, there is only a limited number of research done in these countries, while Malaysia still lack of research on heat stress and physical workload.

In this study, the questionnaire was developed in the following two stages: (i) literature review and (ii) expert panel review. In the first stage, review of the literature was conducted to deduce the definition of heat stress and physical workload while searching for similar like research having the same climate as Malaysia. The database accessed for the literature review included Journal of Safety and Health, Journal of Building and Environment, Emerald, ScienceDirect,

IEEE, Scopus, Taylor & Francis Online and PubMed. The findings were sought using Internet search engines and the following terms in English: heat, heat stress, heat exposure, heat strain, WBGT, worker health, climate change, construction, high rise buildings and Malaysia. No limitations were placed on the date of the published material.

Literature was searched to see whether viable instruments or scales existed for such study as many of the literatures reviewed originated from America, Europe and East Asia countries. Thus, the establishment of own instrument was necessary to be adapted and suited to the working environment in Malaysia.

In the last phase, the questionnaire items will be reviewed for content, coverage and clarity by experts in the field, including ergonomics experts and industry representatives. Feedbacks obtained during the review session will be incorporated into the final version of the questionnaire.

3.0 Results And Discussion

Items generation for the questionnaire were identified in the literature review were useful in the selection of items in the questionnaire. The questionnaire itself is divided into four main parts namely, socio-demographic, physical workload assessment, causal factors of physical workload and heat stress assessment. Part 1 consists of demographic data that categorises the respondents. Socio-demographic information uses the standardized survey classifications and related questions from PGA Group Consulting Psychologists containing an individual's sex, age, and occupation [10]. An Item such as marital status is filtered as deemed unnecessary. Working hours are necessary, taking the 8 hours average working hours as stated in the Malaysia Employment Act 1955. Many workers in the informal sector work longer than eight hours daily, either in the same job or because they have more than one job. The calculation of exposure must take hours beyond the "standard" eight-hour work day into account. Other than that, clothing type is added as it is one of the factors affecting thermal comfort [11]. Work rate is also added in the items as work rate is an important factors when working in hot working environment. If work rate remains constant, then an increase in environmental heat stress increases thermal strain resulting in a rise in heart rate related to the increased thermoregulatory demands on the circulation [12].

Table 1: Items included in the questionnaire developed

Item and concept	Response
1 - 2 : Basic demographic consisting of gender and age 3 - 4 : Years of working in industry	Tick the most suitable option
5 : Medication intake	Yes or No
6 : Working hours 7 : Clothing type 8 : Work rate description	Tick the most suitable option

In Part 2, to measure the physical workload, literatures reviewed are mainly from Asia. It is mainly referred to journals from South East Asia Countries which have similar climates and same working environment in Malaysia for measurement of physical workload namely the Subjective Workload Index (SWI) [13].

SWI objective is to detect hidden risks and problems. It measures the problems commonly faced by workers by the following six main load factors: fatigue, risk perception, concentration, complexity, work rhythm and responsibility. There are also two important factors which influence positive and the negative aspects to compensate the load factors. The factors are as shown in Table 2.

Table 2: Load factors for physical workload

No.	Load factors for physical workload
1	Fatigue
2	Risk
3	Concentration
4	Complexity
5	Work Rhythm
6	Responsibility
7	Satisfaction
8	Autonomy

In Part 3 of the questionnaire, respondents are required to fill in the causal factors during their work. The causal factors are divided into 4 factors. They are body, environment, organisation and others. It involves the factors directly involve in their work. The following items for body and environment for causal factors are as listed in Table 3.

Table 3: Determining causal factors for physical workload

Causal Factors	
Body	Environment
Posture	Heat
Movements	Cold
	Noise
	Vibrations
	Lighting
	Air quality
	Dust

In Part 4, heat stress is assessed using the heat risk factors. Heat stress affects the human body when the body's means of controlling its internal temperature start to fail. As well as air temperature, factors such as work rate, humidity and clothing worn while working may lead to heat stress. When carrying out a risk assessment, there are 7 major factors that require consideration for heat risk factors as in Table 4.

Table 4: Main heat risk factors

No.	Heat Risk Factors	Response
1	Temperature	Not important; slightly important; moderately important; important; very important
2	Humidity	
3	Heat Radiation	
4	Air movement	
5	Workload	
6	Clothing	
7	Acclimatisation	

The heat risks factors together with the explanations are shown in Table 5. For example, the work rate is affected by the amount of body heat generated when the harder the subjects works.

Table 5: Explanations for determing the heat risk factors

No.	Heat Risk Factors	Explanations
1	Work rate	The harder someone works the greater the amount of body heat generated
2	Working Climate	This includes air temperature, humidity, air movement and effects of working near a heat source.
3	Employee clothing and respiratory protective equipment	Employee clothing and respiratory protective equipment- may impair the efficiency of sweating and other mean of temperature regulations; employee`s age, build and medical factors-may affect and individual`s tolerance.

4.0 Conclusion

The questionnaire was established at the end of the study. The questionnaire itself is divided into four main parts namely, socio-demographic, physical workload assessment, causal factors of physical workload and heat risk factors. Based on the literature review done, there have been a lack of research on physical workload and heat stress in Malaysia, thus it is necessary to develop our own instrument to be adapted and used in Malaysia. The limited local research documenting the physical workload and heat stress on construction workers was supported by findings from other parts of the world.

Acknowledgement

The authors would like to acknowledge the support by National Institute of Occupational Safety and Health Malaysia (NIOSH) and study participants for providing necessary information for this study.

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The Impact of Work Rest Scheduling on Prolonged Standing activity in a Malaysian Electronic Company

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Abstract: *In the electronic industry, prolonged standing works are sometimes required continuously for hours. The physical efforts required lead to physiological and psychological fatigue resulting in reduced muscle performance. In order to recover from the muscle exertion, one of the solutions is through the administrative control of a suitable work-rest schedule. In this study, two different work-rest conditions with identical total break time were investigated. An experiment was carried out when ten males' workers were used in each condition. The perception of the operator regarding to the body part discomfort were carried out by exploratory survey. Then, Electromyography (EMG) was used to record the muscle fatigue of the participating workers throughout the experiment. Results indicate infrequent-long rest promotes lesser muscle efforts compared to frequent short. The frequent short rest for 5 minutes (2X5 minutes) at first half of working day was not adequate to promote reduction on muscle fatigue. It was recommended that in order to ensure adequate muscle recovery, a more frequent rest of more than 2 times at the half of day, and more than 5 minutes for each rest should be given to workers.*

Keywords: *prolonged standing, muscle fatigue discomfort, work rest schedule.*

1.0 Introduction

In Malaysian scenario, electronics industry shows a positive growth in manufacturing sector and has been recorded to be as a main contributor on Malaysia's major exports. The increasing demands in the current manufacturing situation increase the challenges for the manufacturer to fulfill the demand with optimum time. The electrical industry has been exposed to many ergonomic risk factors such as improper working posture, excessive time for working hour and repetitive task that may lead to prolonged illness. It was revealed that prolonged standing for handwork (fabrication) process in semiconductor industry has affected the operators to muscle fatigue problem 1. The study performed by Abdullah & Abd Rahman (2009) has shown operators working in semi-conductor industry were exposed to extremely high of ergonomics risk factors 2. They also highlighted the needs on some approaches for reducing this problem such as redesign workstation and promote shorter work duration. Most of Malaysian researches focus area mainly in promoting the guidelines for muscle fatigue such as energetic requirement 3 time-to-fatigue in stamping industry 4. However, there is less number of research studies covers on work-rest scheduling impact for fatigue improvement in Malaysia. By refers to this opportunity, this research will basically focus on reducing muscle fatigue through the implementation of promoting adequate work rest period for operator that highly involved standing activity.

Physical fatigue in industrial environment may happen due to many possible factors and will result in clinical symptoms. According to Grandjean (1979), fatigue in industrial practice can cause clinical symptoms such as psychic instability, fits of de-pression and increased liability to illness 5. Moreover, Grandjean (1979), pointed out that the possible intervention of fatigue may result on work performance, subjective feelings of fatigue and mental test. Regarding to consequences of physical fatigue in industrial set-ting, it is usually denotes to declination on any kind of effort and leads to the loss of efficiency and profit. The effects of fatigue can be in short term and long term condition. In a short term, fatigue significantly affects the ability to do the job. The effect can be seen from body disabilities to performing the task such as slow reaction time, reduce concentration and coordination and finally affect decision making ability. In a long term condition, fatigue may leads to serious physical and health problems such as hear diseases, depression, high blood pressure and as well as work musculoskeletal disorder (WMSD).

In accordance to standing activity perspective, past researchers and medical doctors had revealed prolonged standing was the direct cause of pain and discomfort in the back and lower limbs. This is because a standing posture in long duration makes the muscles and ligaments experience static loading where soft tissues in the joints experience compression, and venous pooling in the leg areas is likely to occur. The fatigue would develop when there is not enough recovery time for the muscles and the soft tissues in the joint, and finally it will cause pain. This may affect to discomfort, distraction and possibly reduced job satisfaction and performance. The study conducted by Ahmada *et al*. (2006), was found that operators spent 87% of their work day in standing task 3. At such long standing hour, it had far exceeded the threshold value of standing time and there is a pronounced risk for increase in pain and discomfort in the lower extremities and lower back. Halim *et al*. (2012), in metal stamping industry study, show that most of the workers are exposed to prolonged standing work activity as they need to stand for a long period of time, involved frequent

movements and large degree of freedom in performing the job 4. The researcher also pointed out among ergonomic interventions is work rest scheduling. This common approach has shown that it can be very effective in minimizing body discomfort. Hence, the intervention on administrative measure such as work rest schedule seems relevant and possible to be done in reducing the risk of fatigue in industry involving standing working activity.

The purposes of this study are to identify the current situation of fatigue level for prolonged standing activity in industrial workplace. Besides that, this study will conduct experiment analysis on muscle activity for prolonged standing with different work-rest setting. In addition, it is to recommend a work-rest schedule that decreases fatigue and improve body comfort.

2.0 Methodology

2.1 An exploratory survey

Before the experiment was started, the questionnaires survey is distributed to all workers involved with standing activity in selected electronics company. The aim of this exploratory survey is to collect the average discomfort body parts for overall population operators working with standing activity. This data will be used as primarily data for conducting the experiment.

2.2 Industrial experiment

Basically, the experiment analyses were classified into three (3) stages. The experiment involved three departments (welding, pressing and magnetron) and all jobs in selected departments required workers to perform in prolonged standing. Therefore ten male productions workers from all departments were selected to participate in this study. The ages, body mass and working experience of the selected workers are as follows:

- Gender: All male
- Age (Mean = 24.6 years, SD = 2.4 years)
- Work experience (Mean = 1.8 years, SD = 0.92 years)
- Body Mass (Mean = 61.4 kg, SD = 7.2 kg)
- Body Height (Mean = 1.60 m, SD = 0.07 m)

Two ergonomics assessment were used in the study to assess the subjective fatigue and muscle fatigue. The operators were asked to answer the questionnaire at the end of working day as to express their subjective fatigue at different work rest setting. At the same time, muscle fatigue was recorded by using EMG equipment. The EMG electrodes were attached on the operator muscles at each working session (morning, afternoon and evening) right after taking a break. The EMG electrodes were attached to six muscles: left and right erector spinae, left and right tibialis anterior, and left and right gastrocnemius.

In the first stage, the muscle performance was measured based on the existing rest schedule currently practiced by the manufacturing company; their resting schedule was accordance to long and infrequent setting (long-infrequent) where break/rest slot happened only once in each working session. Therefore, the actual condition was designated to be as long-infrequent setting condition in this experiment. The characteristics of infrequent long setting were designed with 65 minutes of total rest time for 10 hour working duration per day. One 10 minutes rest breaks allocated at morning and evening session. A 45 minutes lunch break allocated at afternoon session.

In the second stage, the rest schedule was modified to become frequent-short breaks setting (short-frequent). Basically, this setting will involve twice rest slots at morning and evening session whereby lunch break will be at afternoon session. The operators will be asked to perform their job naturally and will be explained earlier regarding to their rest time adjustment. Further explanation on this short-frequent setting can be seen at diagram below. The characteristics of frequent short setting were designed with similar total rest time which 65 minutes of total rest time for 10 hour working duration per day. Two 5 minutes rest breaks allocated at morning session and evening session. A 45 minutes lunch break allocated at afternoon session. Each muscle activity will be taken right after the operators back to start working from rest time. In details, the EMG equipment will be attached to the operator at three working session a day which are morning session, middle of workday and end of workday. The data will be taken at least every 40 minutes of each working sessions during working time.

Third stage involved the data analysis by using statistical analysis. The paired t-test analysis will be used to justify the significance impact at both work rest schedule. The t-test hypothesis testing has been formulated as below:

H0: $\mu d = 0$ (The mean of difference is zero; i.e. frequent short rest is ineffective)

Ha: $\mu d \geq 0$ (The mean of difference is positive; i.e. frequent short rest is effective)

It was expected that the H0 will be rejected when $p<0.05$ (test at 95% confidence level) and it will shows that the short rest schedule is effective. Perhaps, this method will identify which work rest schedule leads to body discomfort and may justify two difference method of work rest in order to improve body discomfort (least body discomfort).

3.0 Result And Analysis

3.1 Actual working conditions

A case study was conducted in an electronics company located in Shah Alam, Malaysia. This company produces microwave product for global market and the activities cover the majority number of in-house production starting from the microwave body frame, internal electronic installation for microwave and as well as microwave part assembly. It can be observed that most of the working activities involve in these departments is standing work activity with highly repetitive motion. Due to the increasing number of production demand, the company needs to be operated at two shifts with ten (10) hours working time at each shift. Moreover, the workers are given 65 minutes of total rest time per shift with three different slot of rest time (morning rest, lunch and evening rest). The standing activity was greatly involved in steel and fabrication department, assembly department, partially involved in magnetron department and slightly involved in PCB department. Most of the operator involved greatly in inspection activity. It was assume that all the job load are common for all departments and pre-chosen on working activity has been made by the helps from the company management.

Figure 1: Workers load and unload parts in standing position and awkward working posture

Figure 2: Workers performed work at standing posture with body twisted

Commonly, all the operators from different department performing load and unloading part from one station to another station. At this work activity, the workers are exposed to standing work activity with body twisted for about 20° to 30° from straight standing position. It was reported that most of the operators felt discomfort at their body back due to frequent body twisted and felt discomfort on the lower legs as the effects from standing too long.

3.2 Exploratory survey result

A modified questionnaire survey was adopted from past study and was used in this survey. At the end of this survey, it was shown that the study has received a positive feedback from the operators with a sufficient total numbers of feedbacks which is 102 feedbacks. The department involvement also shows a great interest from all production departments such as pressing and welding department. The result indicate that the operator felt a higher discomfort on lower extremities (lower body area) compared to higher extremities (upper body area).

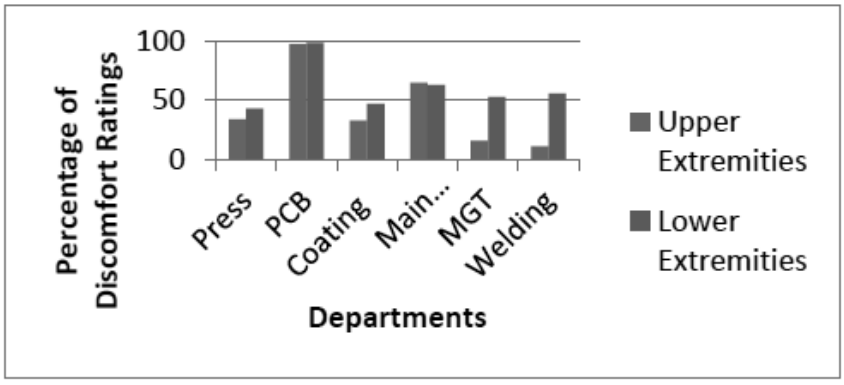

Figure 3: Discomfort area voted by the operators

Figure above shows that lower extremities record higher exposure at almost of departments involved in prolonged standing activity. This indicate that muscle fatigue subjectively exerted at the lower parts of workers body. This study has strongly agreed that prolonged standing activity affect higher on lower extremities compared to upper extremities.

3.2 Experimental result

This section will explain the result of EMG measurement. All the data shown is measured in units of microvolt (μV) where raw muscle frequency has been averaged for all respondents at each working session.

i. Muscle Effort Analysis

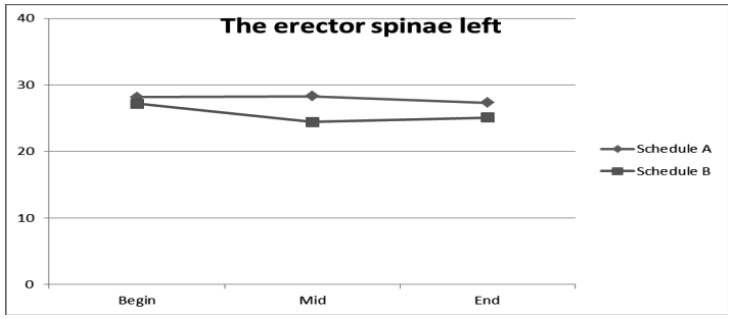

Figure 4: The average muscle frequency of erector spinae (L) muscle at both schedules

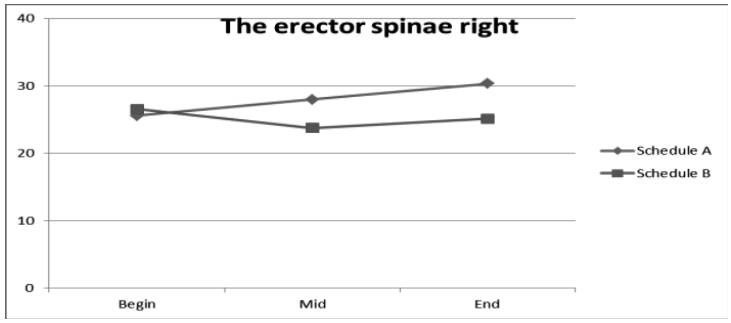

Figure 5: The average muscle frequency of erector spinae (R) muscle at both schedules

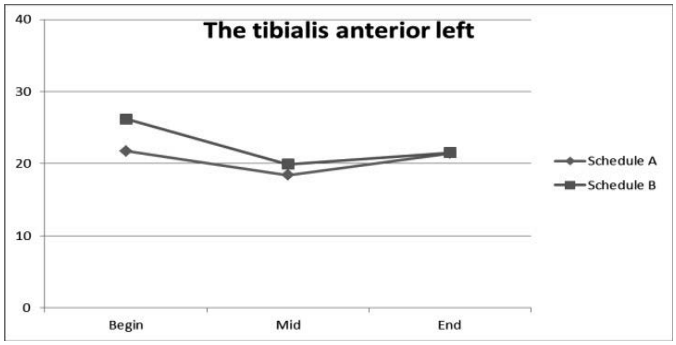

Figure 6: The average muscle frequency of tibialis anterior (L) muscle at both schedules

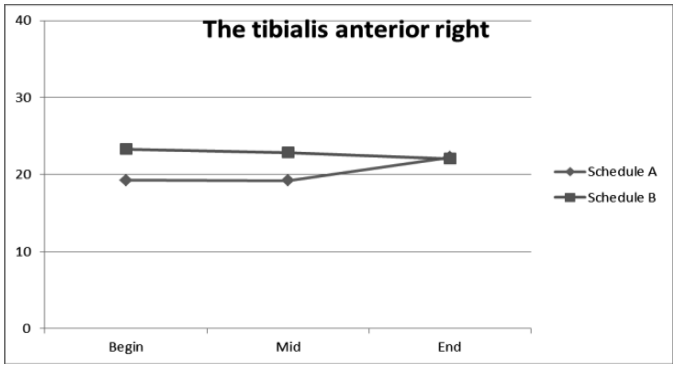

Figure 7: The average muscles frequency of tibialis anterior (R) muscle at both schedules

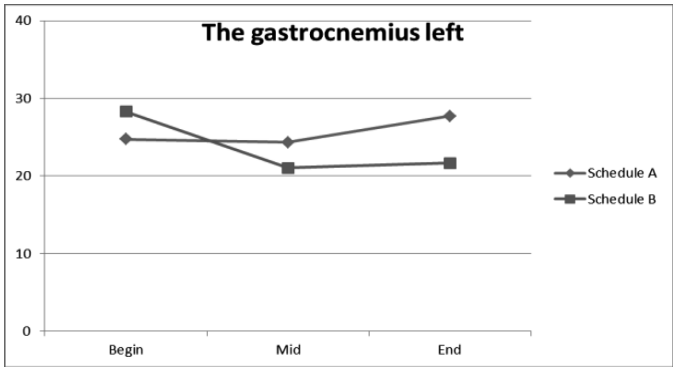

Figure 8: The average muscle frequency of gastrocnemius (L) at both schedules

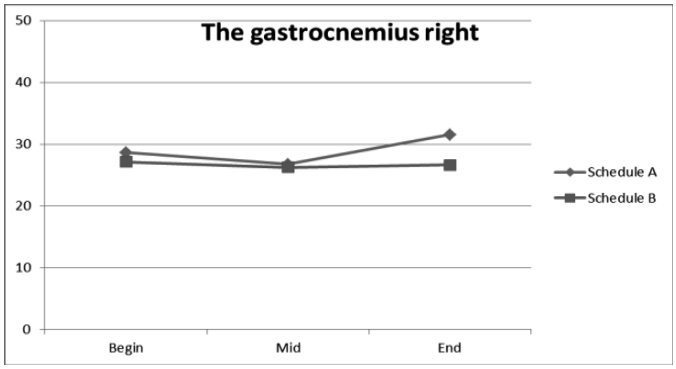

Figure 9: The average muscle frequency of gastrocnemius (R) muscle at both schedules

ii. The paired t-Test Analysis

Table 1: The paired t-test for erector spinae (left)

	Paired Differences			t	df	Sig. (1-tailed)
	Mean	Standard Deviation	Standard Error Mean			
Pair before-after	2.36	7.18	2.27	1.04	9	0.163

Table 2: The paired t-test for erector spinae (right)

	Paired Differences			t	df	Sig. (1-tailed)
	Mean	Standard Deviation	Standard Error Mean			
Pair before-after	2.81	10.26	3.24	0.87	9	0.205

Table 3: The paired t-test for gastrocnemius (left)

	Paired Differences			t	df	Sig. (1-tailed)
	Mean	Standard Deviation	Standard Error Mean			
Pair before-after	1.93	9.12	2.88	0.67	9	0.260

Table 4: The paired t-test for gastrocnemius (right)

	Paired Differences			t	df	Sig. (1-tailed)
	Mean	Standard Deviation	Standard Error Mean			
Pair before-after	2.30	14.00	4.43	0.52	9	0.308

Table 5: The paired t-test for tibialis anterior (left)

	Paired Differences			t	df	Sig. (1-tailed)
	Mean	Standard Deviation	Standard Error Mean			
Pair before-after	-2.03	7.06	2.23	-0.91	9	0.806

Table 6: The paired t-test for tibialis anterior (right)

	Paired Differences			t	df	Sig. (1-tailed)
	Mean	Standard Deviation	Standard Error Mean			
Pair before-after	-2.50	7.03	2.22	-1.12	9	0.855

In overall conclusion, all the analysis shows that p-value is more than 0.05 and it was failed to reject H0. The t-test (paired two sample means) proved that there is no significant difference between on the average of all six muscle when respect to the type of work rest schedule. In other words, the schedule A which is long-infrequent setting promote the optimum setting of work rest schedule when comparing to schedule B (frequent short setting). This non-significant decision has justified that long-infrequent setting produces the common impact of muscle fatigue with frequent-short setting for the company. Since that this company has already implemented the long-infrequent setting in their company work rest schedule, it was practically applicable to maintain this setting as standard work rest setting.

iii. Results Correlation between Questionnaire Surveys and EMG measurement

Based on both assessments, it can be concluded that there was a positive agreement between subjective fatigue and muscle fatigue. This agreement is important so that the qualitative data (questionnaire) could be confirmed and proper plan for improving the worker performance might be taken. EMG data measurement had verified the subjective perception given by the subjects. Below are the results:

Table 7: The comparison status table for left erector spine muscle

Subject	Muscle Effort Differences	Subjective Fatigue	Comparison Status
1	0.69 μV	Fatigue remains constant	Unchanged
2	12.02 μV	Moderate Fatigue to Little Fatigue	Decrease
3	8.26 μV	Fatigue to Moderate Fatigue	Decrease
4	4.62 μV	Little Fatigue to No Fatigue	Decrease
5	-3.95 μV	No fatigue	Increase
6	-11.83 μV	Fatigue to Extreme fatigue	Increase
7	2.42 μV	Fatigue remains constant	Unchanged
8	-1.17 μV	Fatigue to Extreme Fatigue	Increase
9	10.99 μV	Moderate fatigue to Little fatigue	Decrease
10	1.58 μV	Moderate Fatigue remains constant	Unchanged

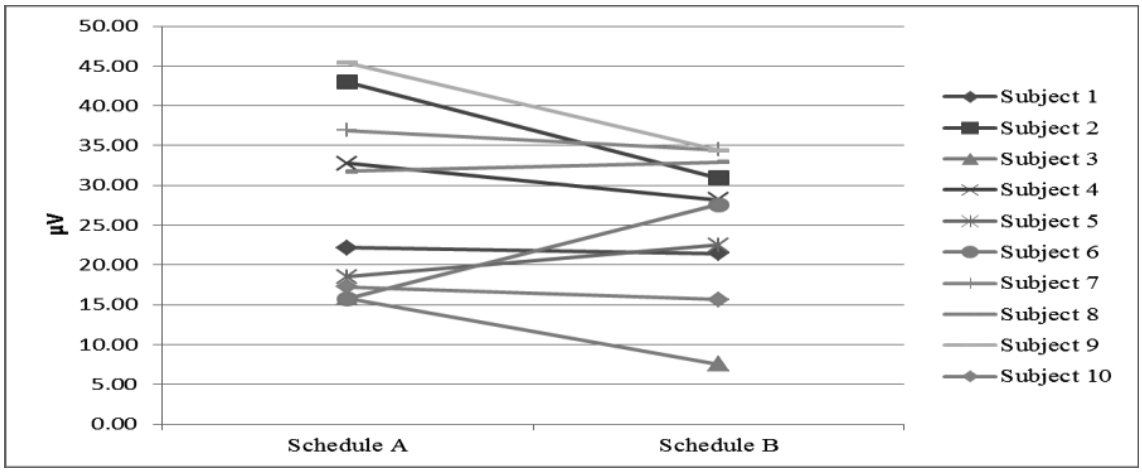

Figure 10: The line chart for differences frequency in left erector spine muscle

In comparison with previous study, there are other divergence result has been found. It was believed that lower back muscle and leg muscle can be improved in different work rest setting. As study conducted by Dieen & Vrielink (1998), they classified long-infrequent setting seems more effective in reducing leg swelling 6. Tiwari & Gite (2005), revealed that work rest schedule with smaller work bout subjectively increase the fatigue on the basis of leg discomfort 7. Other earlier study performed by the Muller-Seitz as mentioned by Kakarot *et al*. , it was found frequent short breaks shows a positive effect compared to infrequent long breaks with the higher of regenerating effect in first third of a break 8,9. As far as we concern, the result on this research has supported the findings in improving leg swelling. It was agreed that long-infrequent setting helps to improve the lower leg muscle such as tibialis anterior muscle and erector spine muscle for prolonged standing activity.

Consequently, the result on erector spine shows the different findings. It was expected that the different result analyses in this study may be affected from the nature of working environment and the disruption on experiment setting due to the factor of production stoppages and sudden breakdown that cannot be avoided. It is suggested that in future, a special experiment setting which simulate the real production line situation can be applied so that it may increase the accuracy of data collection and effective final result.

Moreover, it was found that there is an opportunities for an improvement in terms of muscle fatigue. As reported in section above, erector spine muscle for both sides shows the positive improvement in terms individual's muscle measurement. It can be seen that 7 out of 10 respondent shows a little decrement in terms of muscle efforts while performing the task and even more Ha was rejected at small p-value. Although there is a small improvement shown, this condition has leads us to the possibility on implementing short-frequent rest as a method in reducing muscle fatigue for standing activity in electronics industry. The short rest setting are expected to be designed in more frequent setting (more than two slots for each working session) so that the significant differences can be achieved through smaller working bout. This ideology was aligned with Kakarot *et al*. which resulted to found the slightly lower improvement in frequent short rest setting even though there are no any general activity-rest effects was met 9.The study also documented the additional short breaks prior to a physical load are more beneficial for the human cardiovascular system 10.

4.0 Conclusion

Based on the conducted study, it can be concluded that:

1. It was found that long infrequent rest promotes lesser muscle efforts compared to frequent short rest.

2. The frequent short rest for 5 minutes (2X5 minutes) at first half of working day was not adequate to promote reduction on muscle fatigue.

3. Workers easily tend to fatigue at the end of work day compared to begin of work day.

4. Through exploratory survey, it was confirmed that prolonged standing activity worker in electronic industry are exposed to lower extremities problem.

For future research, it was advisable that:

1. Promote more frequent rest (more than 2 times at the half of the day).

2. Deciding for more than 5 minutes rest at each break slot.

3. Additional rest breaks study might be needed as to promote adequate work rest but need also to consider the productivity implications.

Acknowledgement

This research is collaboration study between University Technology Malaysia and National Institute of Occupational Safety and Health (NIOSH) Malaysia. We would like to acknowledge the Ergonomics Excellence Centre (EEC) division for providing facilities and assistance in performing this experiment. A special thank also goes to selected company for the permission to enter the industry. Finally, the authors would like to thank all the seniors' lecturer from UTM and other university for sharing the ideas during this study was conducted.

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Visual Status in Relation With Occupational Safety and Health Amongst Industrial Visual Display Terminal (VDT) Users in Malaysia

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Abstract: *This study aims to investigate a visual status and prevalence of visual problems in relation to eye safety and health amongst visual display terminal (VDT) users in industries. A visual profile questionnaire (VPQ) and visual tests were conducted on workers from 9 type of industries aged 20 to 60 years old in between October 2015 and June 2016. Workers with a history of exposure to VDT more than 2 hours a day were used as a baseline for recruitment. Respondents who did not complete the visual profile questionnaires (VPQ) and visual tests were excluded from the study. A total of 1214 respondents with mean aged of 39.33 ± 9.80 years have completed the study. Most respondents show moderate to high in vision problems in related to VDT, low knowledge on visual hazards and policy in relation to eye safety and health at the workplace and high percentage of not getting proper eye tests while serving their industries. Visual Profile (VP) is needed as a key indicator to profile eye safety measures and the need for policy to help prevent eye problems and improve employees' productivity at workplace.*

Keywords: *visual profile, ocular occupational safety and health, vision problems, visual display terminale.*

1.0 Introduction

Advancement in technology encourages people to spend hours in front of Visual Display Terminals (VDTs) for both vocational and non-vocational purposes[1] including sharing information, communicating for social network, working or education. The use of VDTs is beyond the desktop computers but including digital electronic screens such as laptop, tablet computers, electronic book readers, smart phones or other electronic devices to assist their routine tasks at the workplace. A recent estimate of internet usage worldwide is reaching 28% of the world population. In 2015, about 20 million Malaysian (68%) and 68.8% in 2016 are using internet and more than 98% of them spending more than 4 hours in front of the computer or digital electronic devices, and more user are expected in the year 2020[2].. And it is estimated that a total population of industrial workers are 13210000 million[3].

Nowadays, workers in all sectors are depending very much to VDTs including both computers and electronic devices to complete their daily tasks. Increase in VDTs usage has increased workers' visual demands to cope with the tasks at work. These increased in visual demands may harm individual eyes and subsequently lead to visual dysfunction or eye diseases[4]. Many studies reported that the prevalence of visual symptoms increase significantly in workers who spent more than 4 hours daily working with the visual display terminals (VDTs) ranged between 46.3% to 68.4% [5–10]. Furthermore, excessive usage of computers or prolonged exposure to digital screens may lead to variety symptoms which have termed computer vision syndrome (CVS) and 64% to 90% of computer users experienced having significant CVS which had an impact on occupational productivity[2]. Thompson et. al[8] indicated that 90% of computer users may experience visual symptoms such as blurred vision, eye fatigue, headache, ocular discomfort, dry eye and diplopia either at near or distance prolonging used of the computers.

Generally, industrial workers are not only using VDTs but also using computerized tools, equipment, or electronic devices at their workplace. Exposure to these instruments may create visual hazards lead them to significant vision problems or eye injuries. Visual hazards may come from tools, environment, chemical, heavy light, radiation or physical setting of the workstations[4]. There are no reliable estimates of prevalence of visual problems, visual hazards and visual demands in relation to eye occupational safety and health of industrial workers in Malaysia against the industrial workers population. The profile of vision problems, visual hazards and increase in visual demands of workers in various industries in relation to eye occupational safety and health to perform their routine tasks at the workplace are not well documented.

In this article, we describe the self-administered visual profile to demonstrate the prevalence of vision problems related to VDT and also to study the knowledge, awareness, visual hazards and vision problems visual demands of the industrial workers who are dealing with VDT and digital screens at their workplace in a various industries in Selangor from October 2015 to June 2016. The findings demonstrate the need for proper vision care and eye safety education at the workplace as well as policy that can protect employees' from visual risks while performing their tasks at the workplace.

2.0 Methodology

VPQ is the self-administered questionnaires comprises of socio-demography, knowledge on occupational safety and health, visual hazards and vision symptoms at the workplace, duration spent in front of the digital screens including the computers and eye and general health for the past 6 months. VPQ has been tested and validated by the experts for internal validity and reliability tests[11]. Meanwhile visual tests include visual acuity and measurement of refractive errors, color vision and contrast test. A cross-sectional study was conducted in between October 2015 to June 2016 at various industries in Selangor. A history of exposure to VDT more than 2 hours a day and aged in between 20 to 60 years old were used as a baseline for recruitment. Respondents who did not complete the visual profile questionnaires (VPQ) and visual tests were excluded from the study. All participants gave signed informed consent before data collection began.

Data for visual profile of respondents was collected by a trained researcher and qualified optometrists who were involved in visual tests. In the visual tests, respondents had gone through a comprehensive eye examination including visual acuity test and measurement of refractive errors, color vision test and contrast test as well as ocular health examination. The socioeconomics background such as age, gender, income status, qualification and involvement in safety and health related works in organization. There was twenty items related to ocular occupational safety and health, comprises of types of occupational, level of involvement with Occupational Safety and Health (OSH), knowledge and awareness related to ocular occupational safety and health, visual hazards, visual demands and vision problems at the workplace. During the period of study from 5th October 2016 to 3rd June 2016, 1522 respondents participated in the visual tests involving 9 types of industries. Out of that, only 1214 (80%) have been completed all the VPQ and visual tests.

Categorical responses (yes or no) were used in visual tests, vision problems and eye diseases section. I mark was given for answer yes and 0 mark for answer no. In other knowledge and awareness section, the responses were recorded using Likert scale 5 ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire consists of 20 items; 10 items for knowledge and awareness in relation to eye safety and health, 6 items for visual tests and 4 items for visual demands related to VDT.

The NIOSH and MSU ethic Committee reviewed and approved protocol and consent forms. The process is followed by performing descriptive analysis to describe the frequency and percentage of sociodemographic characteristics. All analyses were performed using SPSS version 22.

3.0 Results And Discussion

Respondents' response rate for this study was 80% (1214) involving more than 9 industry segments. 79% of them were male and the remaining was female. Most of the respondents were from aged group of 30-39 (34.7%). Malay ethnic background was the major respondents (80%) and majority from income sector in between RM5001 – RM10000 (38.1%) and degree holders (54.7%). Six hundred and sixty-four of the subjects have qualification of degree, followed by two hundred and thirty-three have diploma, one hundred and sixty-seven have only certificate, fifty-seven of the subjects have master qualification and only four have PhD qualification. Based on the income, the subjects were categorized into 4 groups. Group 1 consist of income below than RM 3000, group 2 has income in between RM 3001-5000, group 3 consist of income range in between RM 5001-9999 and last group income more than RM 10000. From the database, 38.14 % of the total subjects have the income in between RM 5001-9999. Another 21% of the subjects have income in between RM 3001-5000 and 16.31% has income less than RM 3000. Only 15.16 % have income more than RM 10000The summary of socio-demographic analysis is shown in Table 1.

Table 1. Respondents socio-demographic (N=1214)

variable		n	(%)
Gender	Male	959	79
	Female	255	21
Age	20 - 29	258	21.2
	30 - 39	424	34.7
	40 - 49	334	27.6
	50 - 60	198	16.2
Race	Malay	868	71.5
	Chinese	146	12.0
	Indian	105	8.6
	Others	80	6.6
Education Level	Certificate or lower	167	13.8
	Diploma	233	19.2
	Degree	664	54.7
	Master	57	4.7
	PhD	4	.3
Income	Less than RM3000	212	15.7
	RM3001 - 5000	255	21.0
	RM5001 – RM10000	463	38.1
	More than RM10000	184	15.1

Nine type of industries are manufacturing, mining and quarrying, construction, agriculture (eg: forestry, fishing, plantation), communication, retail traders, hotels or restaurants, business services and public services. Most of the respondents were from agriculture (28.8%), manufacturing (14.9%), construction (12.5%) and other with a very small percentage. A summary of type of industries was displayed in figure 1.

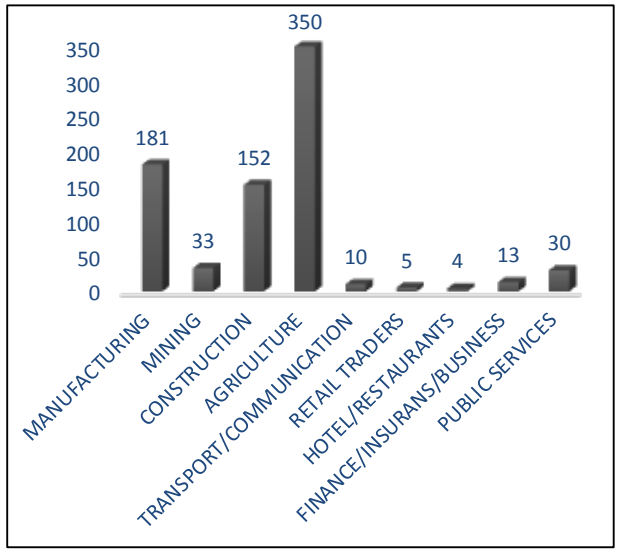

Figure 1: Types of industries

On the measurement of visual hazards and visual risks at the workplace, types of the risks such as radiation, smoke and dust, chemical, hazardous, colour and light perception, high contrast and eye injury were indicated. The highest visual risks at workplace are smoke and dust which is 55.8% followed by chemical with 30.2%, colour and light perception (21.3%), eye injury (20.4%) and hazardous (20.1%). The summary of the visual risks at the workplace was displayed in Figure 2. Other study reported that among the significant visual hazards at the agriculture industries were chemicals, dust, allergen and UV light [8,12]. Sara et. al reported 57% of industry workers exposed to hazards at the workplace [4]. In our study, 40.7 % reported that the working environment have a relation with the eye health. Meanwhile, 36.7 % agree that they know about eye safety at workplace. 34.3 % of the subjects know about the safety glasses and 37.2 % wear the safety glasses during work. 27.7 % agree that policy or law pertaining to eye safety to be implemented in their workplace. Other studies reported that only low knowledge and attitude towards eye safety the workplace such as wearing eye goggles or sunglasses (8.9%)[12-14], face shields or masks (3.8%)[13,] and 35.4% did not wearing any eye protection [14]. This study found that knowledge and awareness on eye protection used was (36.7%) which reportedly higher compared to studies conducted by Quandt et. al (1.6%)[13] and Frost et. al (0.6%)[14].

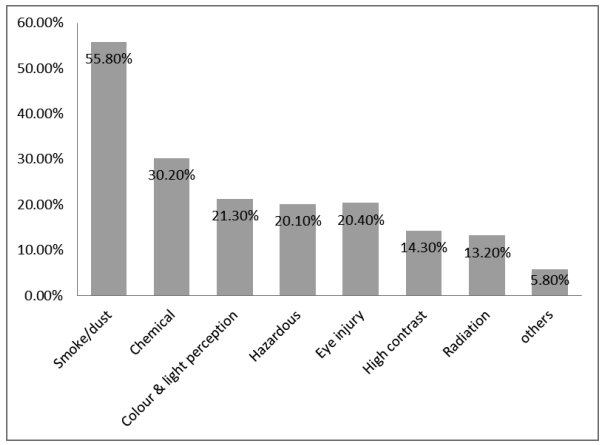

Figure 2: Visual hazards at the workplace

Visual status of respondents in relation to VDT use at the workplace was displayed in Table 2. Among the major visual problems were refractive errors (55.4%), presbyopia (38%), visual fatigue or visual strain (36.7%) dry eyes (34.4%), itchiness (33.4%) and headache (27.4%). Other visual problems were low. Respondents indicated that the visual problems at workplace associated with blurred vision, photophobia, or eye feel dry while performing their tasks in front of VDT. Many studies reported that most of the vision problems in the general population are due to blurred vision[4-9,16]. Workers who have dealt with the computers or digital screens at their workplace reported the most visual problems were visual fatigue (visual strain), photophobia, dry eye and headache [5-10].

Table 2: Prevalence of visual problems related to VDT at the workplace

Variables	n	Prevalence (%)
Refractive errors	673	55.4
Presbyopia	461	38.0
Visual fatigue	445	36.7
Dry eyes	418	34.4
Eye itchiness	405	33.4
Headache	333	27.4
Double vision	208	17.1
Reading Signage	148	12.2
Burning sensation	106	8.7

Blurred vision, photophobia, visual fatigue and headache are also among the top eye health problems experienced by the workers for the past 6 months. Workers reported 49.9% of blurred vision, 33% photophobia, 29.9% visual fatigue, 27.10% headache and 25.8% visual discomfort on the visual problems within the period of past 6 months. Summary of the list of visual problems at the workplace for the past 6 months was displayed in figure 3.

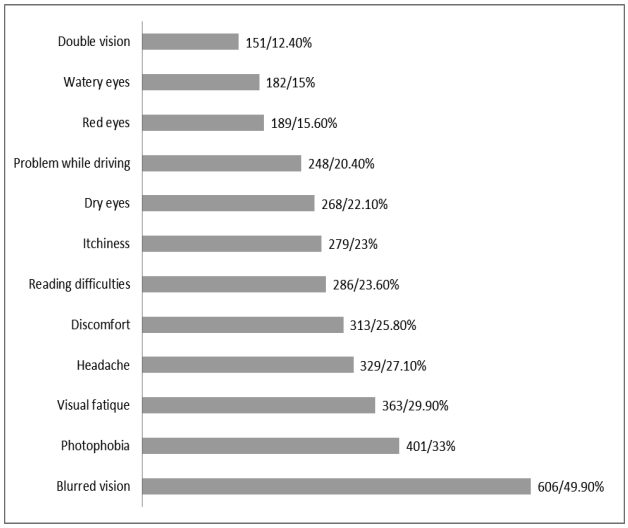

Figure 3: Visual problems experienced at the workplace for past 6 months

This study revealed that 200 of the respondents have low visual demand, 320 subjects have moderate and 210 subject have high visual demand while they perform their routine tasks that require visual abilities (figure 4). 160 respondents spent less than 2 hour per day in workplace, 146 spend about 2-3 hours per day and 148 subjects spend 4-5 hours per

day. 172 subjects claimed that they spend more than 5 hour per day in front of computer during work. Rosenfield (2011) reported that the use of the computers and digital screens among American was 7.5 h for children and 4.5 h for adult[1]. In addition, discomfort experienced during computers or visual terminal display operation, symptoms of CVS may have a significant economic impact. The consequent of the economic impact may be measured by compensation costs, increased in eye care services, lost wages, reduced productivity, medical expenses and in US it cost of 45 to 54 billion dollars annually or 0.8% of gross economic product[15]. This study revealed 18% of workers spent considerably high on visual demands at workplace. However, our finding revealed that more than 41.4% participants have low to moderate visual demands at the workplace (figure 4). This may be due to the low visit to the eye care practitioners. Majority of the subjects never undergo visual test such as visual acuity test, colour vision test and contrast sensitivity test. 71.8% of the subjects never check their vision while 72.2% never do the colour vision test. Only 18% of the subject claimed they already did the contrast sensitivity test (Figure 5).

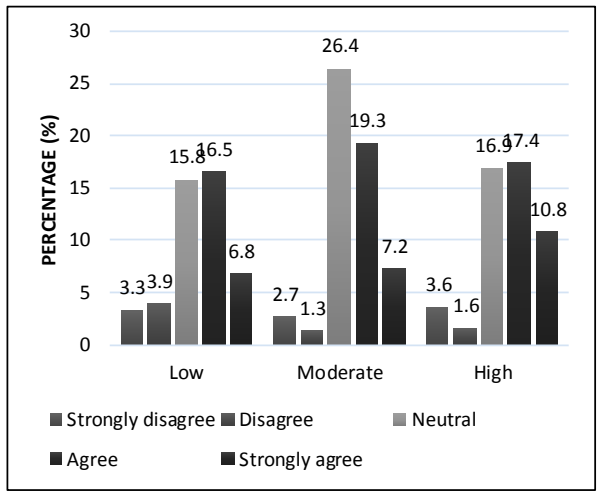

Figure 4: Visual demands at the workplace

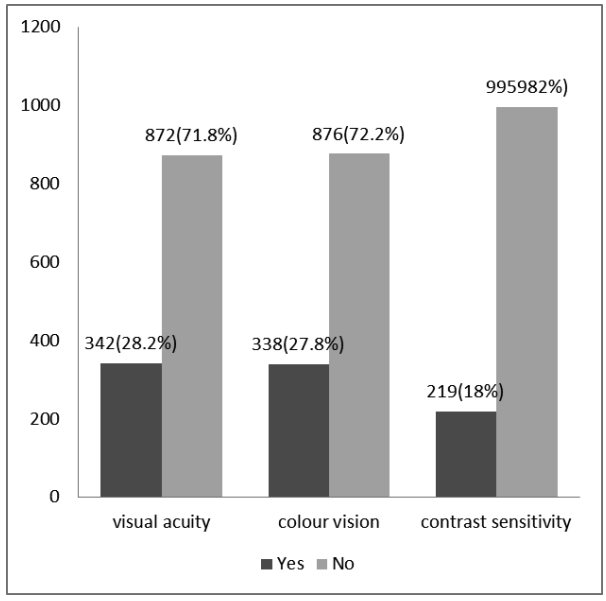

Figure 5: Visual tests conducted on workers at the workplace

Since workers require good visual performance to perform their routine tasks at the workplace, frequent visual test at the workplace is needed. Other studies also show that workers rarely see or never visited any eye care professional to check their eyes annually[4,12]. Visual tests or regular eye test on workers at the workplace is important to avoid exposure to visual hazards that may lead to vision problems, eye injuries or eye diseases which may affect workers' productivity.

4.0 Conclusion

The objective of this study was to determine the visual status and prevalence of the eye visual problems of industrial workers in relation to eye occupational safety and health amongst VDT users through VPQ and visual tests. This study shows high prevalence of the visual problems among VDT users and high percentage of workers did not get proper eye check-up. This result will help the authority, industries' managers, policy makers or health related authorities to provide preventive measures and suitable policy and guideline to help prevent visual problems and improve employees' productivity at workplace.

Acknowledgement

This work was supported through research grant from National Institute of Occupational Safety and Health (NIOSH:11.03/03/NG01_03/VISUALSTATUS/2015). The authors fully acknowledged Management and Science University (Shah Alam) and National Institute of Occupational Safety and Health Malaysia (NIOSH) for financial supports which makes this important research viable and effective.

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An Initial Study of Knowledge, Attitude and Practices (KAP) of Pesticides Use Among Oil Palm Workers in Johor

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Abstract: *An awareness of possible risk factor in pesticides, by changing attitude towards the correct technique during spraying and changing behavior can increase safety of workers safety as well as performance. However, there is a limited study and not highlighted deeply in knowledge, attitude and practices of workers in palm oil plantation issue. Therefore , the objective of this paper is to identify the relationship between knowledge, attitude and practices of pesticides among the plantation workers. The quantitative method were used in this paper whereby 132 respondents as pesticide sprayer which represent 90% of the population of palm oil workers in Johor. The result of spearman correlation indicates that there is significant relationship between knowledge and practices. It shows the common pattern of high knowledge resulting high practices of the workers during spraying the pesticides at plantation. There is no relationship between knowledge and attitude and between attitude and practice of the workers at the workplace. This paper shows that knowledge need to be strengthen in agricultural communities of Johor in order to reduce health problem and sosial issue statistic and prevent for any future accident. Human exposure to pesticides is an important health and sosial issue as it usually results in serious health problems such as stroke, epilepsy, respiratory disorders and cancer. Death has been known to occur in some places as a result of exposures to pesticides. Therefore, more impact knowledge-focused programs need to be arranged and implemented to inculcate the better awareness of pesticides among palm oil workers, as without knowledge, people may become less careful and therefore are exposed to pesticide poisoning and other long term exposure illness in the future.*

Keywords: *Pesticide, Oil Palm, Agriculture, Knowledge, Attitude and Practice.*

1.0 Introduction

Human exposure to pesticides is an important health and sosial issue as it usually results in serious health problems such as stroke, epilepsy, respiratory disorders cancer and etc. Death has been known to occur in some places as a result of exposures to pesticides [1]. (A. Tijani *et al*, 2012).

Pesticide problems have been identified as a major environmental health problem in agriculture sector [2]. (Zainal Abdin et. al,2012). The latest investigation showed a moderate to low awareness among farm workers towards the fate of pesticide residue in soil, in air, on plants and in groundwater. Moderate or low level of knowledge could put farm workers at risk when contact is made with pesticide residue on plants, in soil, and in dust particles after spraying [1]. (A. Tijani et.al, 2012)

According to the World Health Organization, 500,000–1,000,000 people per year around the world suffer from health effects due to pesticide poisoning and about 500–1000 people per year suffer from fatal impacts such as cancer, infertility, and disorders of the liver [3].

Another challenge emerges in tackling issues involved is that the lack of farmers` education and the safety instruction provided are written in unfamiliar language, therefore the farmers are unable to understand, that makes them harder to be able to follow the instruction and warning provided. It was found after that, 30% of farmers-face wipe checked, and Chloripyros and Profenofos were detected [4].

Agricultural workers knowledge, attitude and practice toward the health hazard of pesticides have not been well assessed in Malaysia [5]. Exposure to pesticides can cause a variety of disor-ders and diseases [6].

A KAP survey or instrument contains questions which acquire the Knowledge, Attitude and Practices of respondents for a certain case study. Knowledge is a set of understanding, one's capacity to imagine and one's way of perceiving. The level of knowledge assessed by the survey will assist to identify areas where information and education can be improved. Attitude is the tendencies to act. It is an intermediate variable between the situation and the response to the situation. It helps to explain that among the possible practices for a subject submitted to a stimulus, that subject adopts one practice and not another. Meanwhile practices are the observable individual actions in response to a stimulus. KAP survey provides access to quantitative and qualitative information where questions are predefined and formatted into standardized questionnaire. KAP questions do not reveal only KAP characteristics trait but also the idea that each person has of the problem. These factors are often the source of misconception that may represent obstacles to interventions [7].

The objective of this study is to identify the relationship between knowledge, attitude and practices of pesticides among the plantation workers through KAP survey. With a clear picture of KAP level of pesticide used, appropriate improvement or intervention can be provided to increase safety level of working environment.

2.0 Methodology

To analyze KAP level on pesticide used among oil palm plantation workers in Johor, an appropriate instrument to collect the data was developed in three stages. The first stage involved searching the database for literatures and application of KAP related to pesticide use in agriculture. The findings were reviewed, analyzed and referred to as a guidance in developing items, scale and response option for the new instrument. The instrument is adapted from Skim Amalan Ladang Baik (SALM) provided by Ministry of Agriculture(MoA). The instrument's wordings and word phrases were rephrased in the Malay language for convenience purpose.

The sociodemographic data for palm oil workers comprises of gender, marital status, age, nation, citizen, highest education level, years of experience in current job and years of experience in related works, illness, weight, type of pesticide used, brand of pesticide, frequency of spraying, frequency change of PPE and frequency of training attended. Section B, C and D include the questions on knowledge, attitude and practices of pesticide used from sprayer perspectives. General aspects about brand of pesticide, information of pesticide, health problem related to pesticide, personel protective equipment, legislative, pesticide handling and pesticide storage were included in the knowledge section. The attitude section includes general aspects about information of pesticide, health problem related to pesticide, personel protective equipment, legislative, pesticide handling and pesticide storage and risk taking attitude. Practices section includes information of pesticide, health problem related to pesticide, personel protective equipment, legislative, pesticide handling, pesticide storage, frequency exposed to pesticide, training and treatment.

Categorical responses (true, false) were applied in knowledge, attitude and practice section. Each correct answer was given 1 marks and 0 marks for wrong answer.

This responses were then converted into scoring. Total score was calculated for knowledge, attitude and practice domain. The questionnaire consist of 88 items; 33 items for knowledge, 29 items for attitude and 26 items for practices.

In second stage, pilot test was done on 42 respondents from palm oil workers in Jengka, Pahang. In third stage, the improvised questionnaires were distributed to experts to be reviewed for its content, clarity, coverage and design. The Cronbach's alpha value of this questionnaire were 0.728.

The process is followed by performing descriptive analysis to describe the frequency and percentage of sociodemographic characteristics. Independent sample spearman correlation test was done to see relationship between KAP scores. All analyses were performed using SPSS version 22. The proportion of respondents who answered correctly of each item in KAP were expressed as the good score and correct percentage.

3.0 Results And Discussion

The sociodemographic analysis is done by the completion of 217 respondents data. 88% of them were male and the remaining are female. Most of the respondent ranged from 26 to 30 years old (30.4%). 48.8% and 17.1% respondent were SPM holder and STPM respectively. As for working experience in current industry, 43.8% have worked more than 2 to 5 years while 5.1% have worked more than 16 to 19 years and more than 20 years. On the other hand, 22.1% have 6 to 10 years of experience in work while 16.1% and 7.8% experienced for less than 1 year and 11 to 15 years respectively. The summary of demographic analysis are shown in Table 1 below.

Table 1 Respondents Sociodemographic Characteristics

Variable	N	(%)
Gender		
Male	191	88
Female	26	12
Marital Status		
Married	148	68
Single	63	29
Other	6	3
Age group		
18 – 25 years	46	21.2
26 – 30 years	66	30.4
31 – 35 years	45	20.7
36 - 40 years	16	7.4
41 – 45 years	31	14.3
> 50 years	13	6.0
Race		
Malay	118	54.4
Chinese	3	1.4
Indian	9	4.1
Others	87	40.1
Nationality		
Malaysia	100	46.1
Others	117	53.9
Education level		
Never go to school	30	13.8
UPSR	29	13.4
PMR / SPM	106	48.8
STPM / Certificate	37	17.1
Bachelor's degree	15	6.9
Working Experience		
< 1 years	35	16.1
2 – 5 years	95	43.8
6 – 10 years	48	22.1
11 – 15 years	17	7.8
16 – 19 years	11	5.1
> 20 years	11	5.1
Pesticide spraying frequency		
Daily	130	60
Monthly	37	17
Once per 2 months	26	12
Weekly	17	8
Once per 6 months	7	3
Pesticide sprayer		
Myself	132	61
Hire other	85	39
Reason to change PPE		
Malfunction	168	77
Reach expiry date	46	21
Annually	2	1
Never	1	1
Join OSH training		
Yes	148	69
No	69	31
Medical History		
High blood pressure	13	6.0
Cancer	1	0.5
Asthma	2	0.9
Diabetes	5	2.3
Other	3	1.4
No chronic disease	193	88.9

Malaysian respondents demonstrate highest knowledge mean score frequency comparing to foreigner respondents that are 51% and 49% respectively. This shows that Malaysian respondents are more knowledgeable about brand of pesticide, information of pesticide, health problem related to pesticide, personel protective equipment, legislative, pesticide handling and pesticide storage.

When comparing to attitude and practice mean score frequency for both Malaysian and foreigner respondents, the overall mean frequency for attitude and practice score are 50%. The findings found that although Malaysian respondents has higher knowledge than foreigner, but they did not implement their knowledge during spraying pesticide. The mean score on respondents nationality towards KAP score are shown in Table 2.

Table 2 : Descriptive analysis on responden nationality towards KAP score

Variable	Perspective	Mean	%
Knowledge	Malaysian	74.00	51
	Foreigner	71.56	49
Attitude	Malaysian	80.29	50
	Foreigner	79.93	50
Practise	Malaysian	84.01	50
	Foreigner	85.67	50

In order to determine the correlation between knowledge, attitude and practice, Spearman correlation was conducted. It was found that there is a relationship between practice and knowledge ($p< 0.05$). The results are also very similar to the research of KAP Indonesian Farmers regarding PPE and Pesticide Exposure By M.G.C Yuantari [8], in which knowledge and practice has small portion of significant statistical relationship. Yet, the result of knowledge against practice shows significant correlation.

There were no significant correlation between knowledge and attitude and attitude and practice. The study on printing workers in Hong Kong shows similar result where there are no relationship between attitude effect on practice. The summary of Spearman correlation for knowledge, attitude and practice are shown in Table 3.

Table 3 : Spearman Correlation summary

	K-A	P-K	A-P	Total
No of PairS	57	53	59	169
No of Significance Pairs	6	17	17	40
Spearman Correlation Value between Components (p)	0.846	0.000	0.318	-
Decision	Not Significant	Significant	Not Significant	-

In Indonesia, all farmers as respondents from the three basic commodity, are having low and intermediate level of knowledge, attitude and practice [9], in South America A small percentage (less than 5%) of the farmers uses non-authorized pesticides and their knowledge regarding these pesticides is poor [10].

The results are also very similar to the research of KAP Indonesian Farmers regarding PPE and Pesticide Exposure By M.G.C Yuantari [8], in which knowledge and attitude has small portion of significant statistical relationship.

Another challenge emerges in tackling issues involved is that the lack of farmers` education and the safety instruction provided are written in unfamiliar language, therefore the farmers are unable to understand, that makes them harder to be able to follow the instruction and warning provided. It was found after that, 30% of farmers-face wipe checked, and Chloripyros and Profenofos were detected [4].

4.0 Conclusion

By the data obtained from demography analysis, as most of the respondents' age ranges from 18-35 years old, therefore they have more years to involve in agricultural activities and are prone to determine the agricultural safety and health at workplace. So, more impact knowledge-focused programs need to be arranged and implemented to inculcate the better awareness of pesticides among palm oil workers, as without knowledge, people may become less careful and therefore are exposed to pesticide poisoning and other long term exposure illness in the future.

Acknowledgement

The author would like to acknowledge National Institute of Occupational Safety and Health Malaysia (NIOSH) for the approved fund which makes this important research viable and effective. Special thanks to Faculty of Engineering Technology , Universiti Tun Hussein Onn Malaysia (UTHM) and Centre for Graduate Studies – UTHM in contributing knowledge and input.

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The Ergonomics of Seating Design in Lecture Hall at Faculty of Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM)

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Abstract: *This is a cross-sectional study with the objective to determine the association between complaints Musculoskeletal Disorders (MSDs) and mismatch of the seats in lecture hall of Faculty of Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM). A total of 132 respondents whom were undergraduate students were involved in this study consist of 47 male and 85 female. Eight anthropometric measurement (height, weight, popliteal height, buttock-popliteal height, shoulder height, subscapular height, elbow height and hip width while sitting) as well as five (5) furniture parameter dimensions (seat height, seat depth, seat width, upper edge backrest height and desk height) were taken. Instruments used were questionnaire modified from Nordic Musculoskeletal Questionnaire, Martyn anthropometer set, measuring tape, height scale and weighing scale. Findings showed 51.5% mismatch of seat height, 5.3% mismatch of seat depth, 94.7% mismatch of desk height and 18.2% mismatch of upper edge of back rest. For the prevalence MSDs in the past seven (7) days, 61.4% reported low back pain followed by neck pain (50%) and upper back pain (43.9%). There was significant difference between genders in anthropometric body measurement. Significant association were found between MSDs and mismatch* $\chi 2 = 5.406$, $p < 0.05$. *In conclusion, there was an association between MSDs and ergonomics furniture of lecture halls in FMHS, UPM. Based on the findings, it is recommended that in the event of long lecture hour, intermittent break should be allowed for students to stretch, move or better yet assume different posture such as standing or walk.*

Keywords: *Mismatch, anthropometry, MSDs, university student.*

1.0 Introduction

Furniture is an essential requirement in the classroom where the learning process takes place. Without a proper ergonomics furniture, learning process could be affected (Geldhof *et al*., 2007; Koskelo *et al*., 2007). The anthropometric data on the general population is needed in ergonomics to determine the specification of physical dimension for workplace, furniture, equipment and clothing. It is to prevent a physical mismatch between the dimensions of products and equipment and corresponding to the user dimensions (Bridger, 1995).

According to Gouvali and Boudolus study (2006), most students have difficulties in finding school chairs and table that appropriate with their body dimension. As a result, there were high prevalence of back pain among high-school students and it increases with age whereby the lifetime prevalence of back pain will exceed 50% by 15 years of age (Burton *et al*., 1996; Grimmer and William, 2000; Hakala *et al*, 2002; Van Gent *et al*, 2003; Wedderkopp *et al*, 2001).

The study from Farahani and Shakib (2009) shows that student that spend about 84% to 88% of their time in sitting position. About 41.6% of the students experience pain while sitting at the classroom and about 69.5% experience back pain that occurred after 1 hours sitting and the pain increases with time as the student is in sitting position in the classroom. (Troussier, 1999). Improper design of furniture will result in the lack of concentration hence reduced efficiency and may cause musculoskeletal disorder (MSDs) (Asif *et al*., 2012).

Currently, the furniture at the lecture hall is not standardise among university and lecture hall in term of sizes and types. As there are many studies which showed that the ergonomics problems are associated with the design and function (Parcells *et al*, 1999; Milanese, and Grimmer, 2004; Gouvali and Boudolas, 2006). The improper design of furniture will result in the lack of concentrating that will reduced efficiency and may cause MSDs (Asif *et al*., 2012). However, only a few of such studies that investigated the lecture hall furniture design in Malaysia (Adnan, 2009; Aminian and Fairuz, 2012).

The main objective of this study is to determine the association between Musculoskeletal Disorders (MSDs) complaint and mismatch of the seats in lecture hall of FMHS, UPM

2.0 Methodology

A cross-sectional study was conducted which involved 132 undergraduates students. Purposively sampling technique was used to select the respondents. The respondent name list were obtained from Academic Division, Faculty of Medical and Health Sciences. The inclusive criteria were undergraduate student who have had a minimum of one hour lecture per week in the lecture hall. Written consent was given to the respondents and taken back on the same day as measurement.

A. Questionnaire

The questionnaire used in this study are modified from Nordic Musculoskeletal Questionnaire (Kuorinka *et al*, 1987). The questionnaire is distributed before the measurement of the anthropometry. The questionnaire consist of 3 parts (1) socio-demographic background (2) perception of current lecture hall furniture, (3) history of MSDs and its risk factors and (4) prevalence of MSDs.

B. Anthropometric measurement

The anthropometric measurement were measured by using a Martyn type anthropometer, height scale and weighing scale. Each respondent was asked to sit on the flat surface. Eight (8) anthropometric measurement (height, weight, popliteal height, buttock-popliteal height, shoulder height, subscapular height, elbow height and hip width while sitting) as well as five (5) furniture dimension (seat height, seat depth, seat width, upper edge backrest height and desk height) were taken. The anthropometric measurement were based on method in MS ISO 7250-1:2008. All measurements were taken by the same measures with help on two assistant. Accuracy and reliability of the measurement were achieved by intra-tester reliability test.

1. The following anthropometric measurements of respondents were collected in this study:

    - Elbow height sitting (EHS). The vertical distance from the bottom of the tip of the elbow (olecranon) to the subject seated surface taken with 90^{O} elbow degrees of flexion.
    - Buttock-popliteal length (BPL). The horizontal distance, from the posterior surface of the buttock to the posterior surface of knee or popliteal space taken with 90^{O} knee flexion.
    - Popliteal height (PH). The vertical distance measured with 90^{O} knee flexion, from the foot that is resting on the surface to the posterior surface of the knee (popliteal space).
    - Subscapular height (SUH). Vertical distance of the scapular to the seat surface.
    - Hip width (HW). Horizontal distance between the widest points of the hip in sitting position.
    - Shoulder height (SHS). The vertical distance from a horizontal sitting surface to the acromion.
    - Subscapular height (SUH). Vertical distance of the scapular to the seat surface.

2. The following furniture dimension, the following dimensions were taken:

    - Seat height (SH). Vertical distance from the floor to the front edge of the seat surface.
    - Seat depth (SD). The distance from front to back of the sitting surface.
    - Seat width (SW). Vertical distance of the seal surface.
    - Desk height (DH). The horizontal distance from upper desk surface to the seat surface.
    - Upper edge of backrest (UEB). Vertical distance between middle points of the upper edge of the backrest and the top of the seat.

C. Data analysis

Data collected were analysed by using Statistical Package for Social Science version 21 (SPSS). The furniture dimension were matched with user anthropometric. Table 1 shows the application of measures that used in this study.

Table 2.1: Application of measure

Parameter	Application of measures equation
Seat height against popliteal height	(PH + SC) cos 30° ≤ SH ≤ (PH + SC) cos 5°
Seat depth against buttock popliteal	0.88BPL ≤ SD ≤ 0.95BPL
Seat width against hip width	HW < SW
Desk height against Elbow Height Sitting	SH - sin 5°SD + EHS ≤ DH ≤ (SH-(sin5°SD)) + EHS × 0.8517 + SHS × 0.1483
Upper edge of backrest against subscapular height	SUH ≥ UEB

3.0 Results and Discussion

A. Background information of respondent

Five (5) variable on subject background were collected: age, gender, height, weight and body mass index were reported in Table 3.1. The mean age of the respondents were 21.18 ± 0.86 where the youngest respondent was 20 years old and the oldest was 24 years old. Most of the respondents took part in the study where (64.4%) were female compared to (35.6%) male. The mean height of the respondent were 160.19 ± 7.46 where the minimum height was 147 cm while the maximum height was 177 cm. In terms of weight, the mean was 56.01 ± 9.04 with minimum of 35 kg while the maximum was 80 kg. Majority of the respondent have normal (77.3%) category of BMI while the rest were underweight (10.6%), overweight (10.6%) and obese (1.5%).

Table 3.1: Socio-demographic background

Variable(s)	Mean ± SD	Frequency (%)
Age	21.18 ± 0.86	
Height	160.19 ± 7.46	
Weight	56.01 ± 9.04	
Gender		
Male		47 (35.6)
Female		85 (64.4)
BMI		
Underweight		14 (10.6)
Normal		102 (77.3)
Overweight		14 (10.6)
Obese		2 (1.5)

N= 132

B. Anthropometric measurements differences between male and female

Table 3.2 shows the anthropometric measurements between male and female. There were significant differences in anthropometric data between male and female ($p < 0.05$) for all the anthropometric measurement. The difference was highest for popliteal height ($t = 8.905$, $p < 0.05$).

Table 3.2: The anthropometric data based on gender

Variable(s)	Mean ± SD		t-value
	Male (N = 47)	Female (N = 85)	
Shoulder Height Sitting	59.29 ± 3.83	54.72 ± 2.05	7.605**
Subscapular Height	42.85 ± 2.97	38.85 ± 2.62	8.025**
Elbow height	24.03 ± 1.72	21.94 ± 2.31	5.422**
Popliteal height	44.97 ± 2.25	41.45 ± 2.00	8.950**
Buttock Popliteal height	46.09 ± 3.88	44.68 ± 2.93	2.342*

df = 130

* significant at $p < 0.05$

** significant at $p < 0.01$

C. Seven (7) days prevalence of MSDs among lecture halls user in FMHS.

Based on Table 3.3, the total prevalence of MSDs is 51.77% where the highest prevalence of MSDs is lower back pain (LBP) (61.4 %), followed by neck pain (50.0%) and upper back pain (UBP) (43.9%). Based on gender, male have higher prevalence of LBP as compared to female. On the contrary, the the female had higher prevalence of UBP and neck pain as compared to male.

Table 3.3: Seven (7) days prevalence of MSDs among lecture halls user in FMHS.

Variable (s)	Frequency (%) 7 days prevalence	%		Total MSDs
		Male	Female	
LBP	81(61.4)	64.1	35.9	
UBP	58(43.9)	41.4	58.6	51.77
Neck pain	66(50.0)	40.9	59.1	

N=132

D. Mismatch between sitting anthropometric measurement with furniture at the lecture halls

Table 3.4 reported on match/mismatch of each parameter for seat height, seat depth, seat width, desk height and upper edge of backrest respectively. From the results, the desk height has 94.7% mismatch followed by upper edge of back rest (51.5%) seat depth (15.2%) and upper edge of backrest (5.3%). However, 100% of match is reported for seat width. The mismatch also showed that female experienced higher prevalence of mismatch as compared to male.

Table 3.4: Mismatch between sitting anthropometric measurement with furniture at the lecture halls

Variable(s)	Frequency (%) Mismatch		
	Overall	Male	Female
Seat height against popliteal height	68 (51.5)	6 (8.8)	62 (91.2)
Seat depth against buttock popliteal	7 (5.3)	3 (42.8)	4 (57.2)
Seat width against hip width	0 (0)	0 (0)	0 (0)
Desk height against Elbow Height Sitting and Shoulder height	125 (94.7)	43 (34.4)	82 (65.6)
Upper edge of backrest against subscapular height	24 (18.2)	3 (8.3)	22 (91.7)

N= 132

E. Association between seven (7) days prevalence of MSDs and anthropometry mismatch

Based on Table 3.5, the result reported that χ^2= 5.406, ($p < 0.05$), there is significant association between the total of MSDs prevalence and mismatch.

Table 3.5: The association between seven (7) days prevalence of MSDs and anthropometry mismatch.

Prevalence of MSDs	Match	Mismatch	χ^2	p value
Yes	25	14	5.406[a]	0.02
No	39	54		

Phi (φ) = 0.02 (small to medium strength according to Cohen's Rule of Thumb)

Based on Table 3.6, it shows that only two (2) variables were significantly associated with MSDs; gender and hours of lecture. Specifically, the male was slightly less likely of reporting MSDs as compared to female (OR = 0.174; CI = 0.77,0.39) but at and every increasing hours of lecture increases the odds by almost twice of MSDs being reported (OR = 1.8).

Table 3.6 Factors associated with MSDs

Variables		Crude OR (95% CI)[a]	Wald statistics (df)[a]	p-value
Age		0.867 (0.56,1.34)	0.415 (1)	0.519
Gender	Male	0.174 (0.77,0.39)	17.94 (1)	0.0001**
	Female	1		
BMI	Underweight	1		
	Normal	2.5 (0.24, 50.55)	0.86 (1)	0.550
	Overweight	2.29(0.14, 37.81)	0.34 (1)	0.562
	Obese	3.67 (0.17,77.55)	1.56 (1)	0.404
Hours of lecture		1.8 (0.66, 0.98)	4.51 (1)	0.034*
History of MSDs	Yes	1		
	No	0.47 (0.19, 1.19)	2.528 (1)	0.112

[a] Simple logistic regress

* significant at $p < 0.05$

** significant at $p < 0.01$

I. Discussion

The study found that there are significant differences in anthropometric data between genders among the university student corresponding to study by Karmegam *et al*. (2011), Mirmohammadi *et al*. (2011) and Md. Dawal *et al*. (2012) where the male were had larger anthropometry body dimension as compared to their female counterpart.

In terms of mismatch, various studies has shown that there were significant mismatch between user anthropometric body dimension and seating furniture. Specifically, the study from Aminian and Romli (2012) which involved students from Faculty of Engineering, UPM also shows that there are mismatch between seat height against popliteal height. In addition, the current findings shows that there is a mismatch between seat depth against buttock-popliteal length which were similarly found in various other studies (Ismaila, Musa, & Adejuyigbe, 2013; Amanian & Fairuz, 2013; Asif *et al*., 2012). Besides that, mismatch of desk height and elbow sitting height were also corresponding with the previous studies (Baharampour *et al*., (2013), Asif *et al*., (2012), Qutubudduin *et al*., (2013), Ismaila *et al*., (2013) and Aminian and Romli (2012).

Milanese and Grimmer (2004) describes that the mismatch between seat height and popliteal height can potentially cause the user unable to rest their feet on the floor entirely resulting compression of vascular and neural structures going along popliteal space. Besides that, Chaffin *et al*. (2006) also cautioned the mismatch may prevent the thighs from supporting the weight of the lower leg. On a different anatomical body part, Grimes and Legg (2004) elaborated that mismatch between elbow height and desk height were related with neck and shoulder pain while mismatch between thigh lengths against seat depth is significantly related to the general sitting discomfort.

The higher frequency of MSDs being reported by the female could be attributable to physical and physiological characteristic between male and female (Mohd Azuan *et al*., 2010). According to Katzmaryk *et al*. (1998) male tends to have higher muscle strength as compared to female particularly in upper limb as the muscle strength increase male need less force d to get closer with their maximum capacity while working compared to female that need to use their force more than male (Lewish, 2013). Besides that, Breitchecker *et al*. (2004) also described that the female has heightened body awareness and lower pain threshold which is why female tend to complaint more than male.

In combination with mismatch, pprolonged sitting has been identified as the ergonomics risk factors for MSDs (Lis *et al*. 2007). With increasing lecture hour, the significantly associated prolonged sitting was similarly found in a study by Mohd Nordin *et al*., (2014) and Nyland and Grimmer (2003). Prolonged sitting could potentially increase the spinal compression load (Callaghan & McGill, 2001) and increase the activity of paraspinal muscles (Harrison *et al*., 1999).

No significant association was shown between BMI and MSDs which was similarly found in previous study (Mohd Nordin *et al*, 2014; Chung *et al*, 2005; Grimmer & Williams, 2000; Levangie, 1999) with a systematic review from Leboeuf-Yde (2000) that conclude that was only weak association between BMI and MSDs. It is believed that, the rapid changes of weight within a short period of time may not have an effect on the low back of younger adult (Grimmer & Williams, 2000) and concluded that the BMI does not affect MSDs.

4.0 Conclusion

Based to the data obtained, it can be concluded that the furniture at the lecture halls does not fit the general population of the users based on their anthropometric body measurement. The results shows that the recommended anthropometry body dimension measurement for the seat design should have been as follow: a) Seat height = 38.00 cm b) Seat depth = 38.00 cm c) Seat width = 48.00 cm d) Desk height = 83.00 cm.

Acknowledgement

The author would like to express her gratitude to the respondents who were participated in this study including all staff and personnel in the Department of Environmental and Occupational Health, Universiti Putra Malaysia.

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